Forest Products Journal

COMPLETE UTILIZATION MUST INCLUDE SMELL, P. 303

F. J. ROVSEK COPY

1957 YEARBOOK

Biggest Event of the Year—Part of the 684 Registrants at FPRS 11th National Meeting

lished by the FOREST PRODUCTS RESEARCH SOCIETY BOX 2010, MADISON 5, WISCONSIN

CYANAMID

ANNOUNCES:

Two new low-pressure board surfacing resins

CYZAC* resin 2247
CYZAC resin 2352

New prospects for laminated wood finishing! How would you like to be able to produce, directly on low-density particle board or on hardboard-faced plywood, finishes and surface characteristics approaching those of high-pressure decorative laminates?

This is the prospect opened by Cyanamid's new CYZAC Resins. Print grade or overlay grade laminating papers may now be laminated directly to a particle board or wood surface.

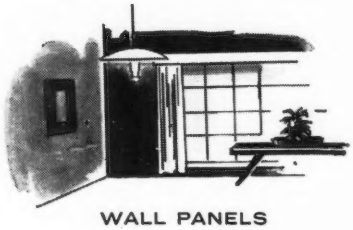
CYZAC Resin 2247 is formulated for impregnating print-grade laminating papers to produce decorative surfaced hardboards for use as wall panels, door panels, cabinets, do-it-yourself applications, low-cost furniture and TV cabinets.

CYZAC Resin 2352 provides the most satisfactory characteristics in impregnated overlay-grade laminating papers. Laminated directly to wood surfaces at moderate cost, it produces a transparent, colorless finish with excellent surface properties; it may even be applied over stained surfaces. The finish gives outstanding beauty and durability to flat working surfaces of tables, dressers, desks and chests. CYZAC Resin 2352 offers new ease of handling and application for producing prefinished lumber products at lumber mills.

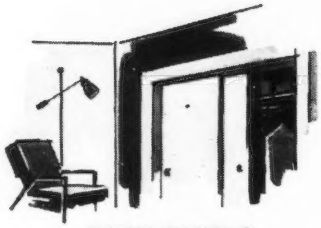
For further details on application techniques and properties, send for our technical data sheet. Your Cyanamid Technical Service representative will welcome an opportunity to help.

*Trademark

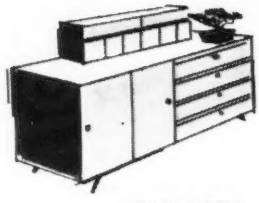
SOME OF THE 999 APPLICATIONS



WALL PANELS



DOOR PANELS



CABINETS

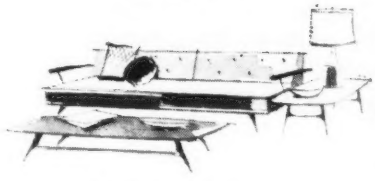


TABLE TOPS

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
328 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

Offices in: Boston · Charlotte · Chicago · Cincinnati · Cleveland Dallas · Detroit · Los Angeles · NewYork · Oakland · Philadelphia St. Louis · Seattle

1907 1957

CYANAMID Plastics and Resins Division

MATERIALS FOR TOMORROW

FPRS

Executive Officers

President

F. H. Kaufert, St. Paul, Minn.

President-Elect

W. Jeter Eason, Memphis, Tenn.

Vice President

E. S. Harrar, Durham, N. C.

Past President

R. H. Bescher, Pittsburgh, Pa.

Executive Secretary

Frank J. Rovsek, Madison, Wis.

•

Regional Board Members

Southeast

W. L. Irwin, Pickens, S. C.

South-Central

W. R. Warner, Warren, Ark.

Northeast

D. K. Saunders, Westbrook, Me.

North-Central

R. L. Hiller, Hartland, Wis.

Northwest

T. S. Veazey, Jr., Butte, Mont.

Southwest

R. H. Berry, Burney, Calif.

•

Publications Committee

Chairman

Edward G. Locke, Madison, Wis.

•

Editorial Staff

Editor

R. H. Hamre, Madison, Wis.

Editorial Assistant

Sandra M. Parrini

THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

Vol. VII, No. 10 October, 1957

CONTENTS

YEARBOOK SECTION

Page

Eleventh National Meeting Attended by 672 ---- 33-A
56 Firms Show Products at FPRS Suppliers Exhibit ---- 39-A
Minutes of the Eleventh Annual Business Meeting ---- 41-A
Report of Section Officers—Executive Board Meetings ---- 47-A
Close Cooperation Stressed by FPRS 14 Divisions ---- 73-A
Minutes of 1957 Division Meetings ---- 73-A
Directory, 1957 Officers and Committees ---- 95-A

RESEARCH

The Challenge of Forest Products Research ---- F. C. Foy 49-A
Everything, Including the Smell ---- L. R. Thiesmeyer 303

PROPERTIES

The Penetration of Light into Wood ---- F. L. Browne and H. C. Simonson 308
Mechanical Properties of Red Oak Related to Drying ---- R. L. Youngs 315
Creep and Other Strain Behavior of Wood in Tension Parallel to the Grain ---- E. G. King 324
The Sorption of Water Vapor by Domestic and Tropical Woods ---- H. A. Spalt 331

WOOD CHEMISTRY

The Distribution of Dihydroquercetin and a Leucoanthocyanidin in a Douglas-Fir Tree ---- W. V. Hancock 335
Recent Advances in Pine Gum Chemistry ---- J. C. Braun and E. L. Patton 338

FINISHING

Moisture Blistering of Paints on Wood ---- J. J. G. Veer 342

GLUES AND GLUING

Dielectric Properties of Resin Glues for Wood ---- D. G. Miller and T. J. S. Cole 345
Production Gluing of Random-Length Core Stock ---- H. B. Reed 352

WOOD PRESERVATION

The Relative Preservative Tolerances of 18 Wood-Destroying Fungi ---- E. B. Cowling 355
How and What to Specify in Preservative Treating Wood for Buildings ---- R. B. Putman 360
An Accelerated Wood-Preservative Termite Study ---- A. E. Lund 363

SEASONING

High-Temperature Drying of British Columbia Softwoods ---- F. W. Guernsey 368
The Equilibrium Moisture Content—Relative Humidity Relationships of Selected Native and Foreign Hardwoods ---- N. C. Higgins 371

PATHOLOGY

The Appearance and Decay Resistance of Discolored Aspen ---- R. L. Hossfeld, J. C. Oberg, and D. W. French 378

MATERIALS HANDLING

Lumber Handling with Fork Trucks and Straddle Carriers ---- M. B. Dickey 382
Tree-Length Wheeled Skidding ---- D. W. Gray 386
High Pressure Pneumatic Conveying in the Wood Product Industries ---- W. C. Smith 390

COMPOSITION BOARD

Effect of Several Production Variables on Modulus of Rupture and Internal Bond Strength of Boards Made of Green Douglas-Fir Planer Shavings ---- J. W. Talbott and T. M. Maloney 395
Some Practical Aspects of Particle-Board Core Stock ---- D. E. Schmidt 53-A
The Importance of Proper Chipping ---- G. Massé 55-A

CONSTRUCTION

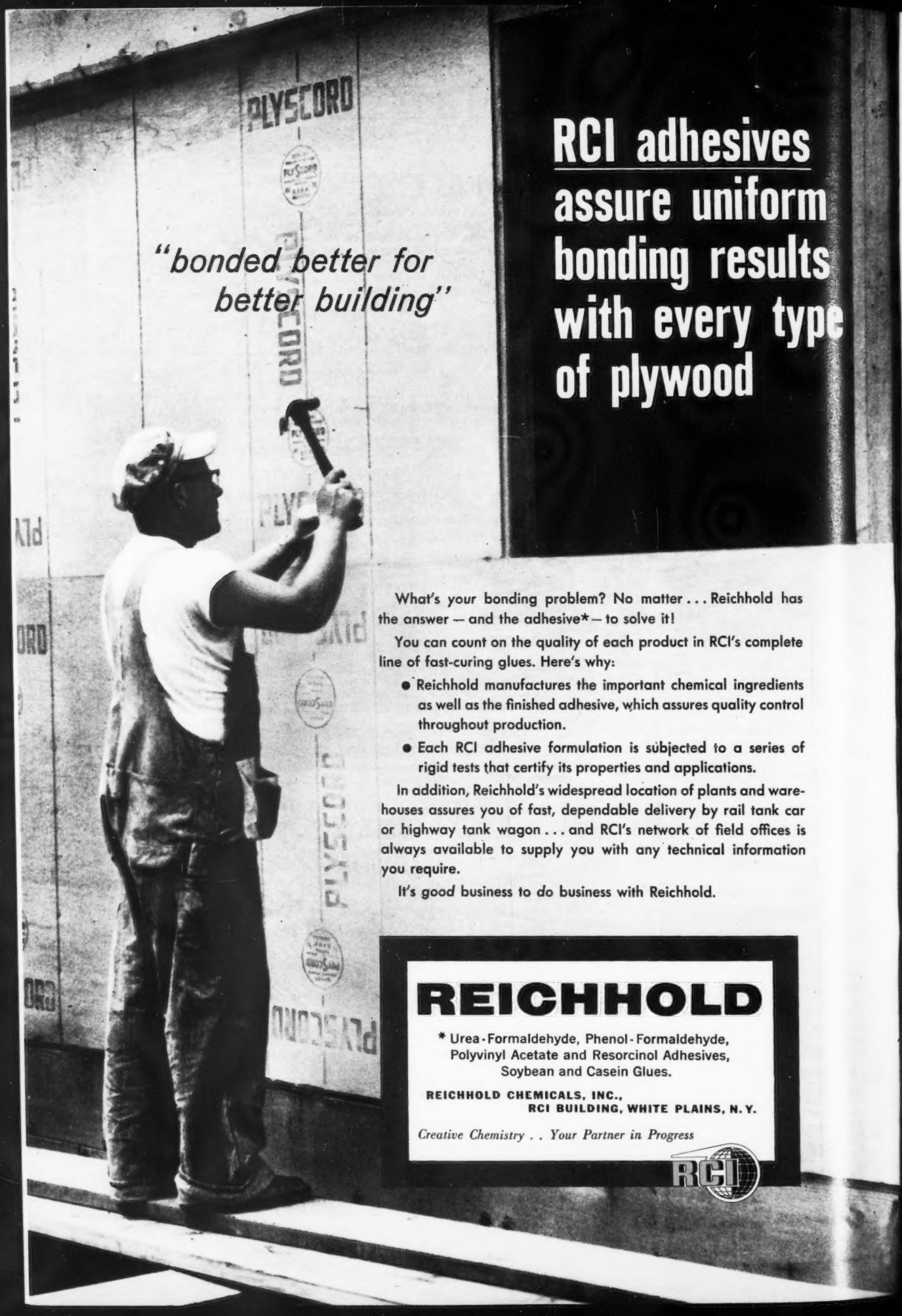
The Building Research Institute and the Building Research Advisory Board ---- H. Horowitz 57-A

EQUIPMENT

Developments Leading Toward a Better Power Chain Saw ---- J. J. Conroy 59-A

DEPARTMENTS

FPRS News—Digest ---- 29-A
Around the World in Forest Products Research ---- 61-A
Review of FPRS Contributed Paper ---- 63-A
Abstracts from Current World Literature ---- 64-A
Meet FPRS' 100 Company Supporting Members ---- 94-A
Index to Advertisers ---- 104-A



RCI adhesives assure uniform bonding results with every type of plywood

What's *your* bonding problem? No matter . . . Reichhold has the answer — and the adhesive* — to solve it!

You can count on the quality of each product in RCI's complete line of fast-curing glues. Here's why:

- Reichhold manufactures the important chemical ingredients as well as the finished adhesive, which assures quality control throughout production.
- Each RCI adhesive formulation is subjected to a series of rigid tests that certify its properties and applications.

In addition, Reichhold's widespread location of plants and warehouses assures you of fast, dependable delivery by rail tank car or highway tank wagon . . . and RCI's network of field offices is always available to supply you with any technical information you require.

It's *good* business to *do* business with Reichhold.

REICHHOLD

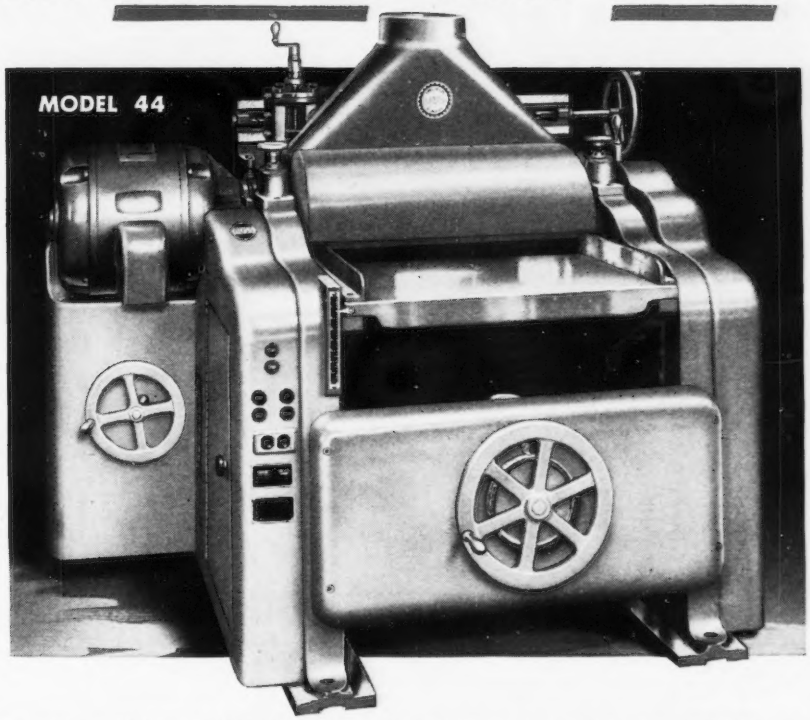
* Urea-Formaldehyde, Phenol-Formaldehyde, Polyvinyl Acetate and Resorcinol Adhesives, Soybean and Casein Glues.

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N. Y.

Creative Chemistry . . Your Partner in Progress

RCI

Buy BUSS and get the PLANER that EXACTLY suits YOUR needs!



NO OTHER LINE OFFERS SO MANY MODELS AND SIZES

When you buy a BUSS planer you not only get a machine that will give you the best job of planing in the shortest possible time, but a machine that is virtually custom built to *your* particular production requirements. For example: Our Model 44, 4-roll and Model 66, 6-roll single surface cabinet planers are available in a total of *13 sizes as compared to two to four sizes of machines in the same category offered by other planer manufacturers. In addition, we have all the other models shown below, available in various capacities. Consequently, when you buy a BUSS planer you never need pay for extra capacity you do not need. But, on the other hand, when extra large capacity is a real asset, you'll find that BUSS offers a planer of larger capacity (52" width) than any other on the market. Obviously, we are exceptionally well situated to provide you with the planer that will net you the greatest return that can be had from an investment in planers. Let us consult with you on your requirements. Bulletins on request.

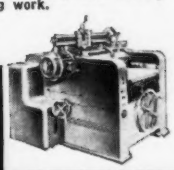
*** MODEL 44 CAPACITIES:**
26, 30, 36, 40, 42, 50, and 52 inches x 8 inches.

*** MODEL 66 CAPACITIES:**
30, 36, 40, 42, 50, and 52 inches x 8 inches.

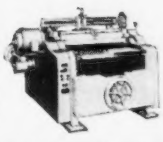
THERE'S A BUSS PLANER TO EXACTLY SUIT YOUR NEEDS

6 MODELS
40 SIZES

No. 4-L Single Surface, medium sized planer for first cutting and finishing work.

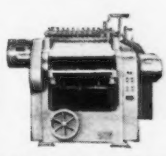


No. 66 Single Surface, 6 roll planer for first cutting and finishing work.



No. 88 Double Surface, 8 roll planer for first cutting and finishing work.

No. 55 Heavy duty Double Surfacer for planing rough lumber.



MICRO-SURFACER for planing hardboard and other very thin materials.

BUSS
SINCE 1862
MACHINE WORKS

PLANER SPECIALISTS EXCLUSIVELY

EIGHTH STREET • HOLLAND, MICHIGAN

MACHINERY & TOOLS

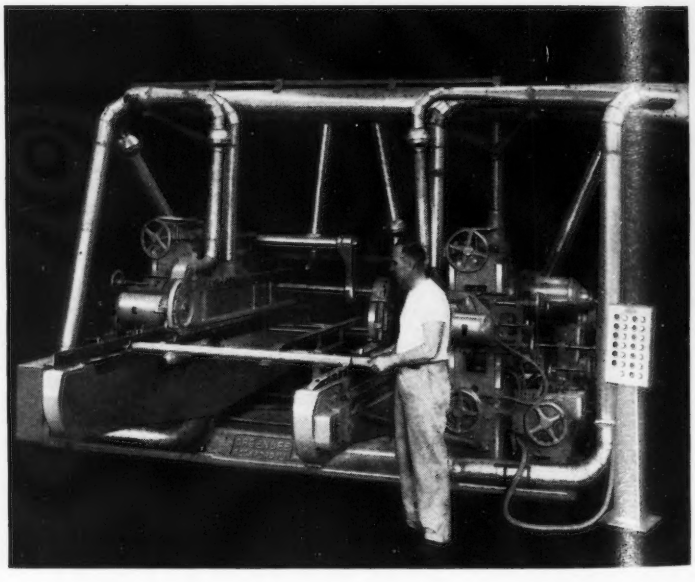
GREENLEE

NO. 545 DOUBLE-END TENONER

Holds To Exact Sizes On Production Runs

Eliminates COSTLY Hand-fitting

Piece after piece, the work produced on this machine will pass the most rigid inspection standards. What is more, the benefits of this consistently accurate machining carry over through the entire manufacturing process. The Greenlee "545" works to extremely close tolerances because it is built with the same precision and skill as world-famed Greenlee machine tools. Let us show you how this close-tolerance machine can reduce costs at every step in your production. Write today for complete information.



GREENLEE MACHINES FOR PLANING, SHAPING, TENONING, MORTISING, BORING AND SAWING

Put a Profit in Your Woodworking With Greenlee Machines

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION WMMA

GREENLEE BROS. & CO.

1760 TWENTY-FIRST AV.
ROCKFORD, ILL.

Scroll sander polishing inside edges of maple figure-8 chair backs with 100-J (2/0) CLOSEKOTE Garnet Cloth.

New "SPUR ACTION" abrasive belt gives a "mirror-polish" *and outlasts all others 3 to 1.....*

This is just one of the many production methods using "Spur Action" belts developed and proved at "Abrasive Tech" to save time and material. If you have a production or finishing problem, just phone the nearest Behr-Manning office for a date.

There are 17 "Abrasive Tech" Methods Rooms well-equipped with the latest equipment of all manufacturers (Behr-Manning does not make or sell machines) located at: Atlanta, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Detroit, Grand Rapids, High Point, Indianapolis, Los Angeles, Teterboro, Camden, San Francisco, Seattle, St. Louis, and Brantford, Canada. Main office and plant: Troy, N. Y. For Export: Norton Behr-Manning Overseas Inc., Troy, N. Y., U.S.A.

BEHR-MANNING CO.

TROY, N. Y.

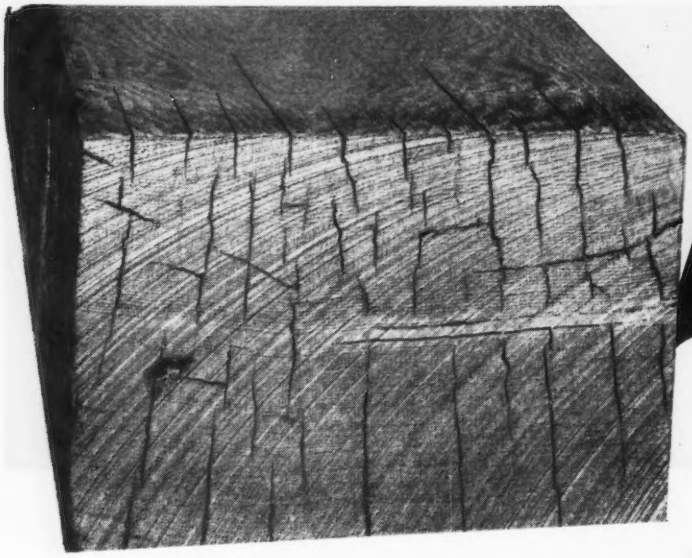
A DIVISION OF NORTON COMPANY

NORTON ABRASIVES

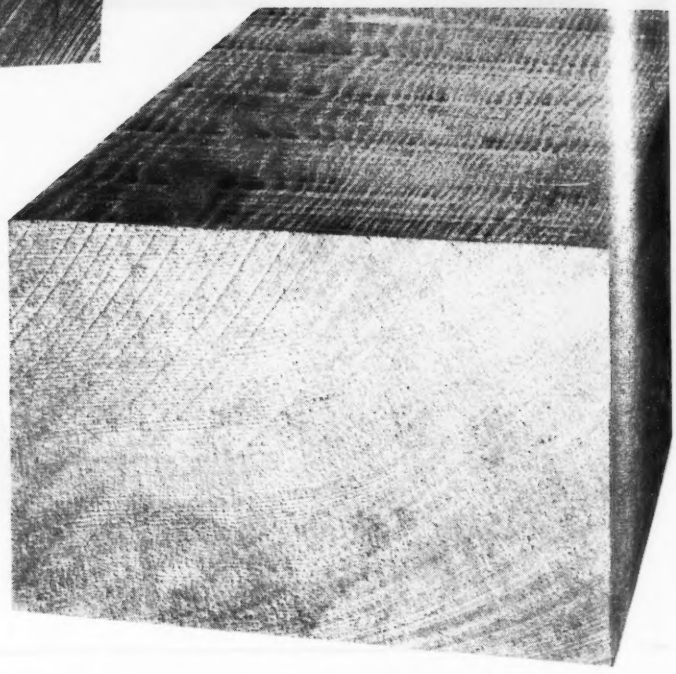
BEHR-MANNING PRODUCTS: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

NORTON PRODUCTS: Abrasives • Grinding Wheels • Grinding Machines • Refractories

BEHR-MANNING ®



End checks are expensive!



CHAPMAN®

SEALTITE prevents them!

LOW-COST END-COATING FOR LOGS, LUMBER, TIMBERS

- Controls end-checking and reduces losses due to degrade
- Economical to use . . . costs just about one cent or less per square foot, applied
- Easy to apply by spray, brush or swab
- Effective for kiln drying as well as air seasoning
- Permits safe cold-decking of logs to insure uninterrupted mill operation
- Available in clear liquid and red and green colors
- Extremely stable in storage
- Prompt shipment in 52-gallon drums from Chapman Chemical Company plants and warehouses throughout the United States and in Canada and Mexico

MAIL COUPON FOR NEW ILLUSTRATED BOOKLET

CHAPMAN®

SEALTITE END-COATING

CHAPMAN CHEMICAL COMPANY

Leading manufacturer of wood preservatives

Memphis 1, Tennessee

Minneapolis, San Francisco, Portland, Ore., Charlotte, N. C.

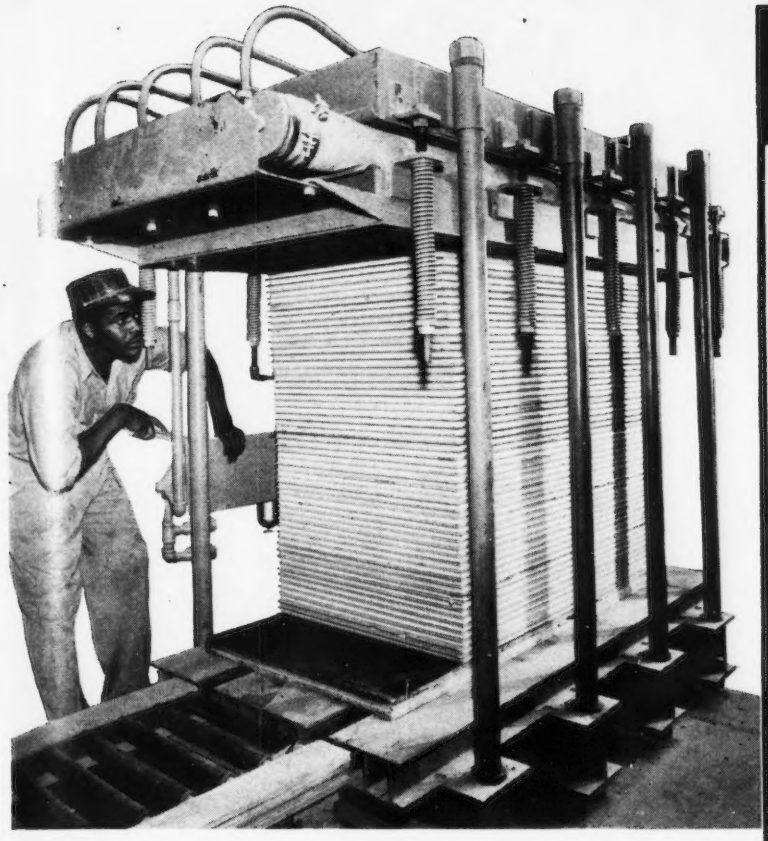
Chapman Chemical Company
Memphis 1, Tenn.

Send booklet on
SEALTITE to:

Name_____

Address_____

_____



FOUR ANSWERS TO YOUR LAMINATING PROBLEMS

We've taken your production problems . . . and designed machines to answer those problems. In hundreds of progressive plants throughout the world, the four presses shown here are the basis for modern production techniques in moderate pressure bonding operations. Perhaps one of these job-engineered presses will answer your laminating problem. The specific product bulletins will give you more detailed information. Write for them today!

AIR HOSE LAMINATING PRESS—BULLETIN 11-D

For cost-conscious manufacturers—a high production press for moderate pressure bonding with vinyl and other adhesives. Platen size 30″ x 30″ to 54″ x 120″.

ROTARY PRESS—BULLETIN 11-C

The ideal press to laminate dissimilar plies when bonding with *rubber base instant contact bond adhesive*. Roll widths to 62″; pressing speeds 10 to 60 FPM; max. pressure 7500 lbs.

MOTORIZED LAMINATING PRESS—BULLETIN 11-E

A rugged and dependable laminating press for use with all kinds of cold glue. It's especially popular for laminating composition board, flush doors and plastic laminates and can be used with or without retaining clamps. Capacities 36″ x 36″ to 48″ x 120″.

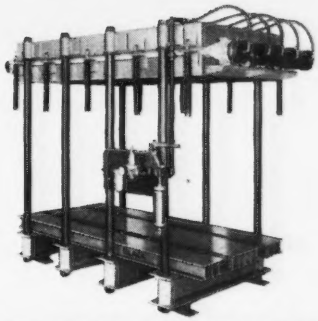
HYDRAULIC LAMINATING PRESS—BULLETIN 11-P

Preferred for laboratory, experimental and light production work. Standard sizes from 1 to 12 sq. ft. Pressures to 100 tons.

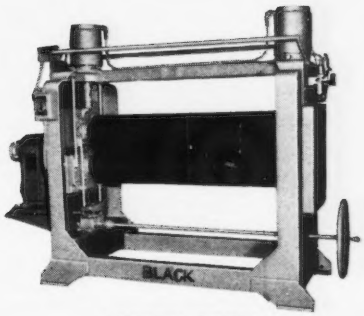
THE BLACK BROTHERS COMPANY, INC.

MENDOTA 8, ILLINOIS

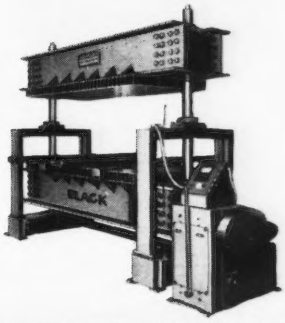
BLACK BROTHERS COLD PRESSES



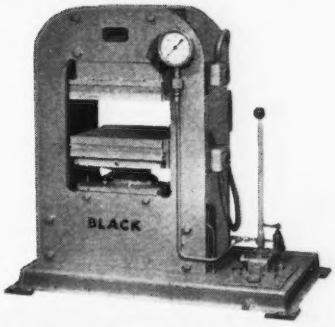
AIR HOSE LAMINATING PRESS



ROTARY PRESS



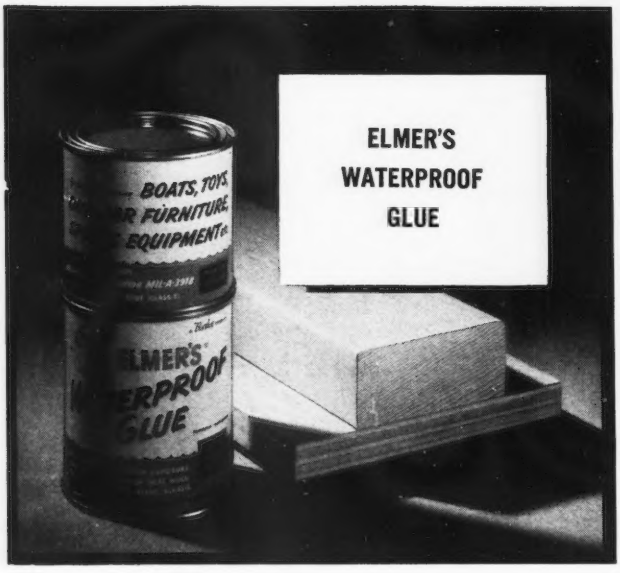
MOTORIZED LAMINATING PRESS

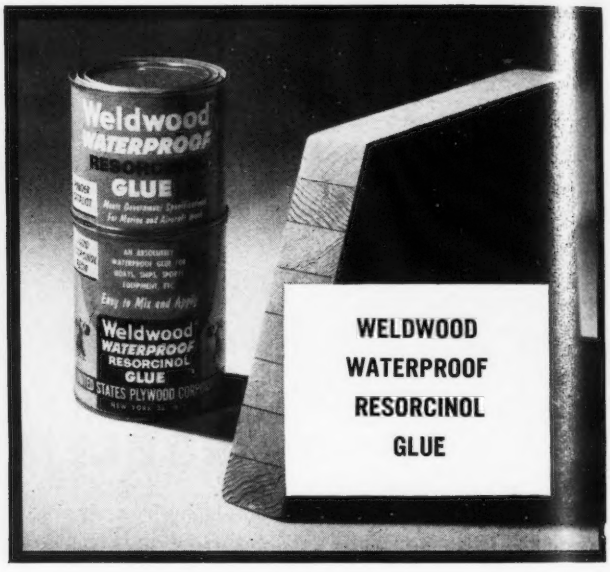


HYDRAULIC LAMINATING PRESS

RESORCINOL ADHESIVES

for permanent, waterproof bonding





BOTH of these well known products contain Koppers high-quality resorcinol—a vital ingredient that assures long-life, waterproof bonds which remain stronger than the wood they join.

Available for small, on-the-spot bonding jobs in handy, shelf-size containers, these versatile adhesives are also sold to volume users. United States Plywood offers resorcinol adhesives under the name – Weldwood® Waterproof Resorcinol Glue—both in bulk and small size containers. The Borden Company sells do-it-yourself quantities under the name—Elmer's Waterproof Glue; resorcinol adhesives in bulk amounts are sold by Borden under the trademark—Cascophen®:

Versatile resorcinol adhesives are ideal for bonding all kinds and sizes of wood parts—from broken chair backs to laminated keel timbers. That's why the containers shown above are stocked at boat supply shops, hardware stores, lumber dealers and other retail outlets.

Koppers sells resorcinol adhesives in bulk quantities under the trademark PENACOLITE®.

KOPPERS COMPANY, INC., Chemical Division, Pittsburgh 19, Pennsylvania

KOPPERS

KOPPERS CHEMICALS

To form the new flake board "Cedarwood"® in its Everett, Washington plant, the Columbia Hardbord Co. uses a 10-opening Washington press, loader and unloader for completely automatic operation.

The following hardboard and particle board plants are using, or have on order, Washington press and accessory equipment:

ABITIBI POWER & PAPER CO. LTD.
Sturgeon Falls, Ontario, Canada

AMERICAN PARBOARD CORP.
Black Mountain, North Carolina

CAROLINA FOREST PRODUCTS INC.
Wilmington, North Carolina

COLUMBIA HARDBORD CO.
Everett, Washington

GEORGIA–PACIFIC CORP.
Coos Bay, Oregon

GRAY PRODUCTS COMPANY
Waverly, Virginia

JOHNS–MANVILLE PRODUCTS CORP.
Natchez, Mississippi

MASONITE CORP. OF AUSTRALIA LTD.
Eildon, Australia

POINSETT LUMBER & MFG. CO.
Pickens, South Carolina

POPE & TALBOT INC.
Oakridge, Oregon

TIMBER ENGINEERING CO., INC.
Washington, D. C.

Washington automatic hot press equipment has industry-wide acceptance

Many plants like Columbia Hardbord Co. are profiting from the engineering and manufacturing experience of Washington Iron Works in building an automatic machinery package for particle board production. All units in a Washington press installation are designed and built to meet specific production requirements of board size, forming speeds and minimum cycles, in addition to being integrated with the plant layout of each customer. *Write for details.*

HOT PLATE PRESSES • AUTOMATIC PRESS LOADERS AND UNLOADERS • COMPLETE DRY PROCESS HARDBOARD FORMING EQUIPMENT AND SPECIAL MACHINERY

WASHINGTON IRON WORKS, 1500 Sixth Ave. South, Seattle 4, Washington

WASHINGTON IRON WORKS

We would like further information without obligation, on Washington hot presses and accessory equipment for hardboard, particle board and flake board production.

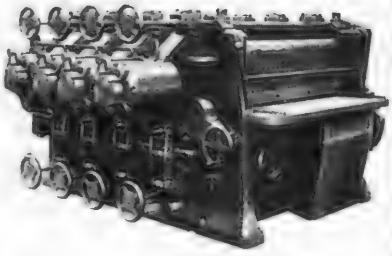
Name _____

Address _____

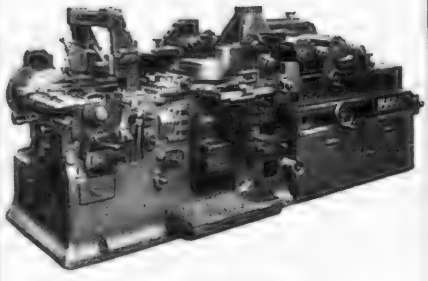
City _____ Zone State _____

No other company in the world makes as many types of woodworking machines for production use as

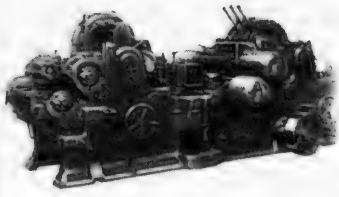
YATES-AMERICAN



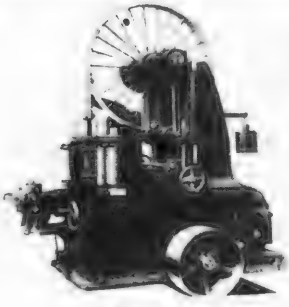
S800 Roll Feed Sander



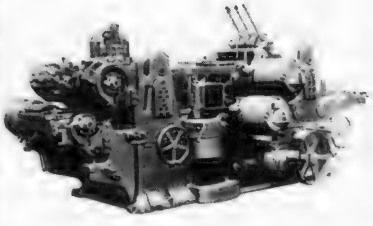
C99 Electric Moulder



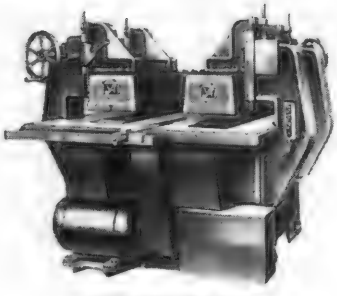
A62 Planer-Matcher



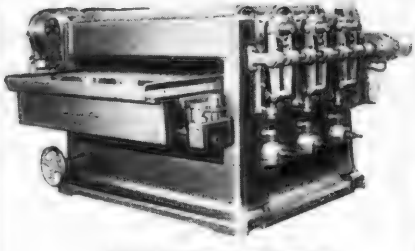
V60 Band Resaw



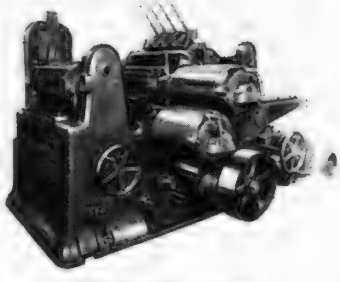
A20 Planer-Matcher



G82 Twin-Rip Saw



S333 Endless Bed Sander



B24 Double Surfacer

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION WMMA

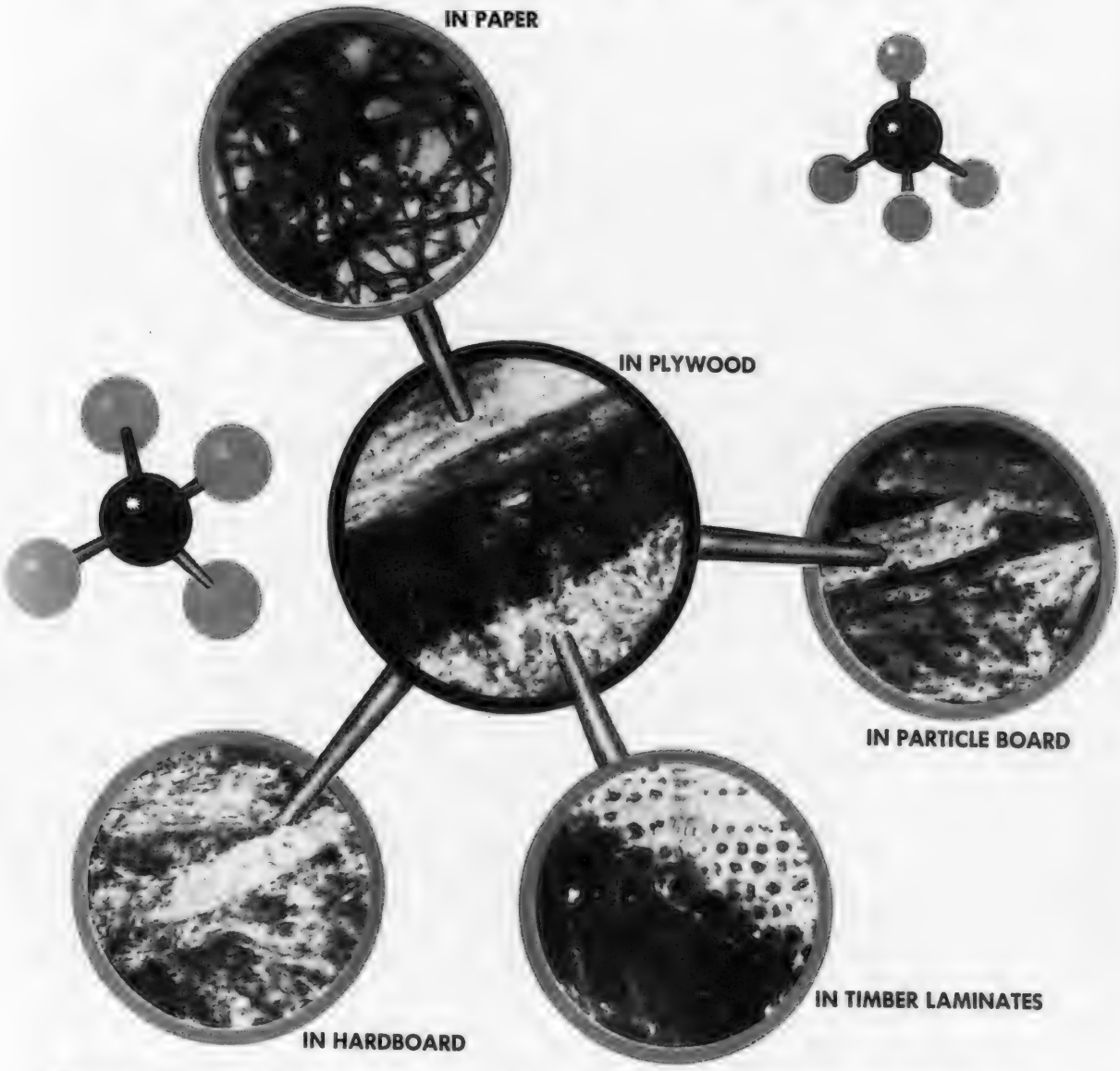
Write for data sheets and information on how these Yates-American machines can reduce costs and increase output in your plant.

YATES-AMERICAN

BELOIT, WISCONSIN

Branch offices: Chicago • Atlanta • Portland, Oregon

TO IMPROVE PRODUCTION
TO INCREASE PROFITS . . .
Improve Your BONDS



Discovering more about the art and science of wood and fiber bonding is our objective; passing on this knowledge to our customers and using it to make better adhesives and resins is our business. Our laboratories and field engineers can show you why A-M bonds are stronger and more dependable; they can aid you in planning rapid, economical, high quality production. Modern forest products are engineered.

AMERICAN-MARIETTA CO.

ADHESIVE, RESIN & CHEMICAL DIVISION

3400-13TH AVE. S. W., SEATTLE, WASH. • PORTLAND, ORE.
EDMONTON, ALTA. • NEW WESTMINSTER, B. C. • CHICAGO, ILL.

A-M®
THE INDUSTRY BUILDER

AMERICAN-MARIETTA CO.
ADHESIVE, RESIN & CHEMICAL DIV.
3400-13TH AVE. S. W.,
SEATTLE 4, WASH.

Please send me the following publications without obligation:

☐ AMERICAN-MARIETTA—THE COMPANY & ITS PRODUCTS

☐ MASTER LIST OF A-M TECHNICAL PUBLICATIONS

NAME

STREET

CITY

ZONE STATE

LAUXITE* MF300, a Monsanto melamine resin adhesive, will produce completely waterproof bonds on plywood and edge-glued lumber. The bonds meet military as well as rigid civilian requirements for waterproof plywood manufactured by elevated temperature methods.

With a durability comparable to phenolic resins, Lauxite MF300 has a faster cure rate, lower platen temperatures, higher permissable veneer moisture cont nts, longer maximum assembly times, light colored lue lines, excellent storage stability, and easier clean- p.

Investigate Lauxite MF300 for your critical bon ing needs. Write for samples, complete technical dat to Monsanto Chemical Company, Plastics Division, l om 1647, Springfield 2, Mass.

Other Monsanto Adhesives include:

LAUXITE 326 *A melamine-urea adhesive for hot press gluing when greater boil resistance is desired.*

LAUXITE MF325 *A specially formulated powdered melamine resin binder for granulated wood.*

RESINOX *phenolic resins, liquids and compounds, for granulated wood molding and hardboard.*

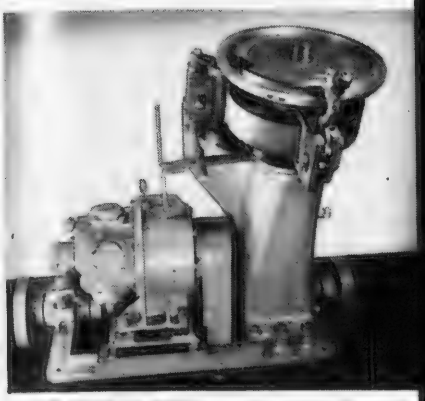
LAUXEIN *versatile protein adhesives with specific formulations to meet varied bond requirements.*

LAUXITE *urea resin glues, both liquid and powder, for high water resistant bonds.*

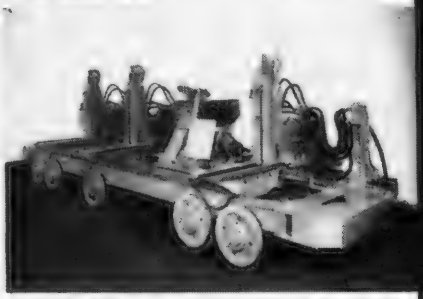
Monsan o

*LAUXITE, RESINOX, LAUXEIN: REG. U.S. P OFF.

ew Filer & Stowell Head Rig Machinery



AIR MOTOR SET WORKS — *Now preferred* as the most accurate setting and fastest receding set works. Rugged, simple construction eliminates costly repair. Easy to convert present set works to Filer & Stowell Air Motor Drive Set works. Write for bulletin #301.



AIR DOG CARRIAGES — Only Filer & Stowell Air Dog Carriages have the "Dual Movement", which eliminates miscutting by pulling the dogged logs back firmly against the head blocks. No faster dogging mechanism exists than Filer & Stowell inside the knee *Air Dogs* with top and center teeth.

SHOT GUN CARRIAGE FEEDS — Proven on more installations to be the *fastest and least costly drive* for sawmill carriages to get more lines per minute. Equipped with all the latest safety devices, these guns may be powered by steam or air. Find why smart sawmill operators are going back to this time proven method of driving Log Carriages. Write for Bulletin #303.

Now . . . increase production of better lumber at lowest cost. Filer & Stowell brings you the most accurate and durable Head Rig Equipment available, with the greatest capacity for more lines per minute.

To eliminate losses from "downtime", the *headache* of all mill men, Filer & Stowell *Head Rig* Machinery is recommended *the world over.*

BAND MILLS — Only Filer & Stowell Band Mills have *all* the features needed to fulfill the desire of sawmill operators for the *most sensitive* and *durable* Band Mills. Ask for bulletin #300.

World's largest builders of sawmill machinery since 1856

THE FILER & STOWELL CO.

147 E. Bochar Street • Milwaukee 7, Wisconsin

Service...

Service...

Service...

Service

from Montreal to Miami—from Bangor to Burbank, usually in a matter of a few *hours*—rather than *weeks* or *months!* With Diehl machines in thousands of woodworking plants scattered all over the nation, qualified service representatives cover some 120,000 miles per year—*by air* . . . thus assuring fast, dependable service when it is needed *most!*

Service

for Diehl machines no matter when they were built! Diehl has made the finest precision woodworking equipment available since 1909, and can manufacture and *install* parts for any machine during its normal operating life.

Service

is a vital segment of Diehl's far-flung operations, and only Diehl offers such streamlined, dependable service to the woodworking industry! So when you next need a modern, profit-making woodworking machine, see your Exclusive Diehl Representative. He'll show you *dependable* Diehl machinery, backed by *dependable* Diehl service.

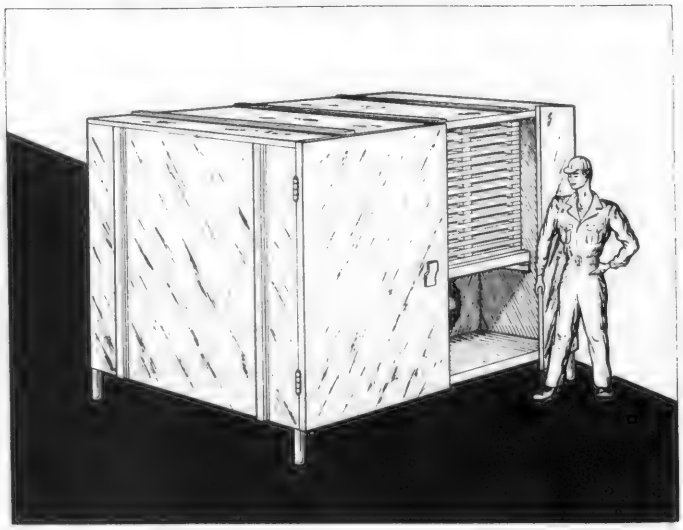
THE G. M. DIEHL MACHINE WORKS, INC.
Wabash, Indiana

Diehl

DIEHL *Service* STANDARD OF COMPARISON IN THE WOODWORKING INDUSTRY

New -- Inexpensive

The MOORE Small-Capacity CABINET DRYER



SPECIFICATIONS:

- **Dryer Size:**
  8 ½ feet wide
  6 feet deep
  7 ½ feet high
- **Capacity: Up to 500 board feet, in lengths up to 8'–0".**
- **Moore Wedge-Seal panel joint construction.**
- **Housing of double-aluminum insulated panels.**
- **May be heated with steam or electricity.**
- **Complete with fans and controls.**
- **Fabricated, assembled and test-run before shipment.**

Here is an inexpensive, small-capacity cabinet dryer—designed by Moore—with many uses:

—Seasonong lumber and other forest products

—Curing laminated glue joints

—Drying foundry cores

—Drying wood chips and other materials for determining moisture content

—Experimental laboratory drying

Write today for complete information and prices on the Moore Cabinet Dryer.

CROSS-CIRCULATION DRYERS — SINCE 1879 — MOORE DRY KILNS — THE WORLD OVER

MOORE DRY KILN COMPANY

Oldest and Largest Manufacturers of Dry Kilns and Veneer Dryers

JACKSONVILLE FLORIDA | BRAMPTON, ONT. CANADA | VANCOUVER, B. C. CANADA | NORTH PORTLAND OREGON

ALE • HIGH POINT • SHAWANO • WEST MEMPHIS • KITCHENER • LA CHUTE • LANSDALE • HIGH POINT • SHAWANO • WEST MEMPHIS • KITCHENER • LA CHUTE • LANSD

The MARK of America's Finest Wood Glues

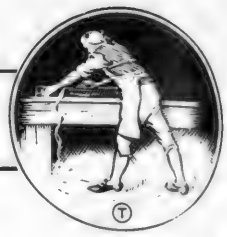
This Trade Mark is a familiar one to American Wood Workers for it identifies wood glues that have attained a standard of excellence often imitated but never duplicated.

Backed by almost 60 years of wood gluing experience and the most outstanding Gluing Service staff ever assembled in the industry, Perkins Glues are known to be consistently uniform in quality and dependability.

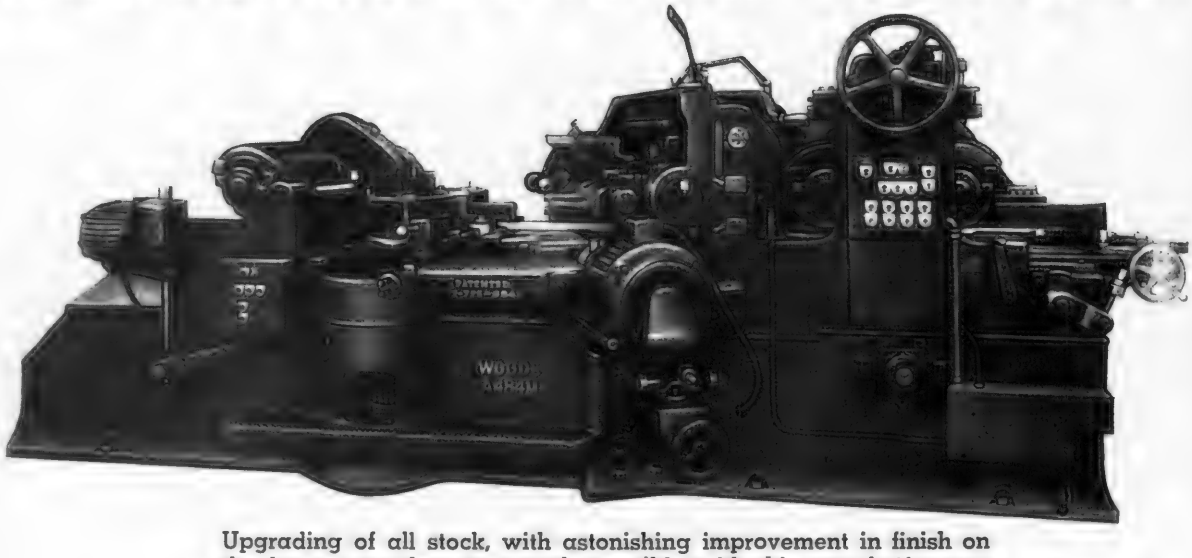
The result is that a Perkins Glued product is always a better product.

PERKINS GLUE COMPANY
Lansdale, Pennsylvania

Serving the Industry Since 1852



It's Revolutionary!
A-484M DIAGONAL PLANER and MATCHER



Upgrading of all stock, with astonishing improvement in finish on the lower grades now made possible with this revolutionary DIAGONAL PLANER and MATCHER.

DISTINCTIVE FEATURES

- ★ Elimination of sniped ends.
- ★ Smoother finish around knots and cross grain, with less tendency to loosen knots.
- ★ Continuous support of stock on bed plate before and after cut on bottom head.
- ★ Less lead required in guide as angle cutterhead serves to hold stock against the guide fence, preventing side friction, feed roll wear and edge sniping.
- ★ Less power consumption in feeding stock.
- ★ All operating adjustments can be made from the front or working side of machine.
- ★ Wide face helical gears for feed works, assuring continuous tooth mesh and quieter operation.
- ★ Independent quick green stock lift for first bottom feed-in rolls.
- ★ Bottom head cylinder can be pulled out for changing knives without disassembling motor.
- ★ Individual ball bearing housings for all cutting units.
- ★ All ball and roller bearings housed in dustproof housings. Grease lubricants for roll bearings. Regulated wick oil feeders used on all cutting units. Forced feed lubrication for feed gears.

Write Today for the A484-M Booklet

S. A. WOODS MACHINE CO.
27 DAMRELL STREET
BOSTON 27, MASS.

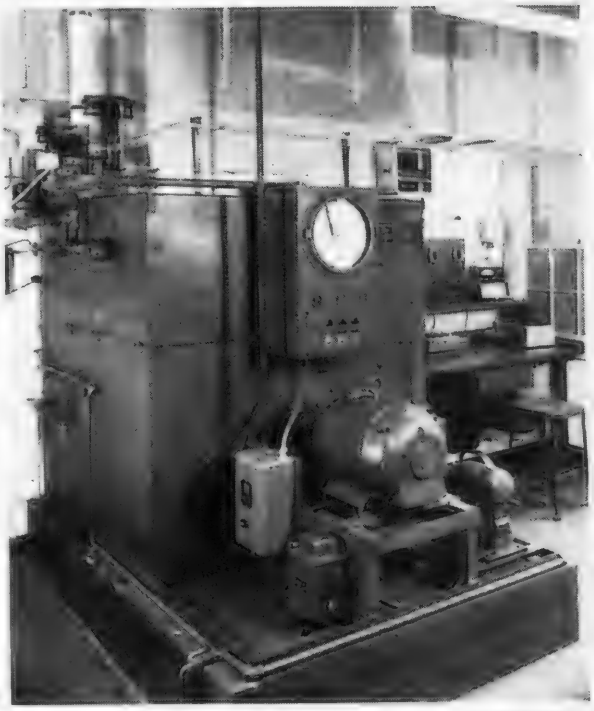
INSIDE IS A **PACKAGE** FULL OF OUTSTANDING KILN-DRYING ADVANTAGES

NOW... YOUR PLANT CAN AFFORD THIS faster and better kiln drying system. For Orr & Sembower's Packaged Automatic DRYALATOR costs less than conventional drying systems. And actual comparison records prove it cuts drying speeds over ordinary systems.

READ WHAT DRYALATOR USERS SAY! "The Dryalator has given us excellent service, is simple to operate, and is giving us complete satisfaction"... "It is the most efficient and cheapest method of drying lumber in use today"... "Particularly impressed with speed of drying lumber"... "Produces brighter lumber and does not darken it nearly as much as the conventional type kiln"... "has proved to be a great asset to our business".

YOUR KILN CAN BE CONVERTED to packaged Dryalator operation quickly and inexpensively. Dryalator brings automation to lumber drying, allows assembly line production and reduced inventories.

GET THE FULL STORY! Write today for our new Dryalator bulletin.



O&S PACKAGED **DRYALATOR**®

WOOD AND LUMBER DRYER

ORR & SEMBOWER, INC.

Morgantown Road, Reading, Pa.

Builders of Heat Transfer Equipment for over 70 Years

For FAST, EFFICIENT DRYING *of*

VARIOUS WOOD PRODUCTS, VENEERS & FIBRE BOARDS

8 Line Gas Fired Coe Fibreboard Dryer

Wet end 10 section, 4 line, 12 ft. roll Model 48 Coe Veneer Dryer.

Industry Depends Principally Upon

COE DRYERS

Since the first Coe continuous dryer was built and sold in 1902 the design, construction and efficiency of these machines have been consistently improved.

Machines are now available in various types and sizes for drying fibreboard and veneer for many purposes including plywood.

Coe Dryers are conservatively rated and sold on a **guaranteed performance basis.** Almost without exception, performance has exceeded the guarantee.

Our engineering and research departments are always willing and anxious to cooperate in the development of drying processes for new wood products.

The COE MANUFACTURING CO.

PAINESVILLE, OHIO

WARNING!

You're missing a sure bet if you don't use NCC Casein Glues!

. . . where lower costs are important. One lb. of NCC casein glue powder makes 3 lbs. of glue.

. . . where long storage life is desired. When stored in a cool, dry place NCC casein glues maintain their properties for long periods.

. . . where temperatures cannot be rigidly controlled. Unlike resin glues, NCC casein glues can be mixed and used at any temperature above freezing. Elevated temperatures, however, do speed up setting time.

. . . where extra strong "bite" is needed. Ideal for many applications because of their penetrating "bite," NCC casein glues are especially effective on oily or resinous woods and other hard-to-glue surfaces.

. . . where moisture-resistant bond is required. Every shipment of NCC casein glue is thoroughly laboratory-tested for water-resistance before leaving the plant.

. . . where a fast-setting glue can increase production. Several of our casein glues are sufficiently quick-setting to give *fast* production with *less* pressure equipment and curing space required.

Recommended Uses For NCC Casein Glues

- fine veneering
- heavy face-laminating
- flush doors
- millworking
- doweling laminated timbers
- hardboard, fiberboard
- plastic-to-wood

NCC Casein glues meet Specifications CG-456, 14122 or MMM-A-125

National Casein

National Casein Company, 601 W. 80th Street, Chicago 20, Illinois

National Casein of New Jersey, Broad and Fulton Streets, Riverton, New Jersey

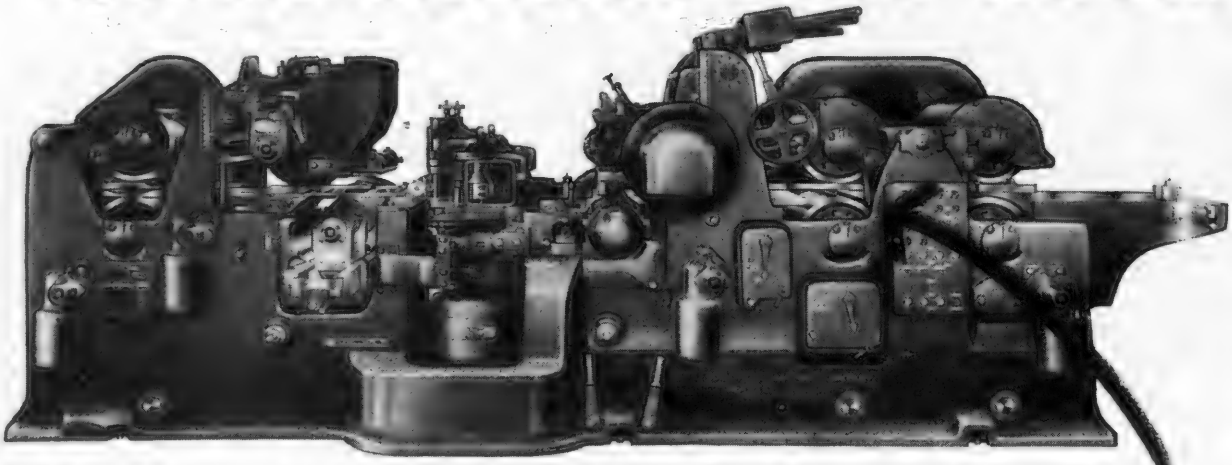
Write for more information on National Casein's complete line of casein and resin glues

STETSON ROSS

CLAM SHELL

TRADEMARK

QUICK CHANGE FEED ROLLS



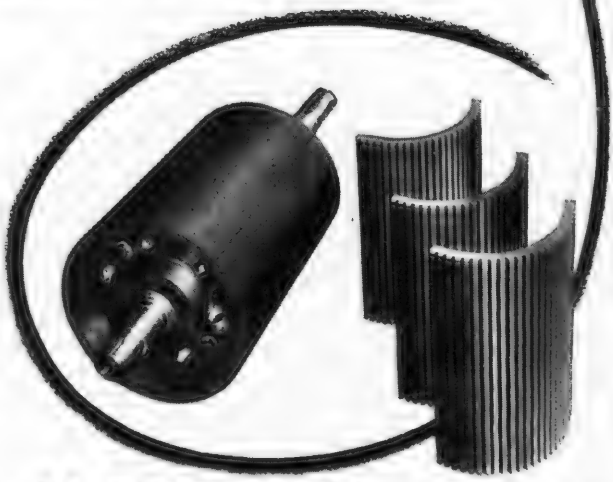
Save Many Hours of Lost Production and Reduce Your Maintenance Costs

Here's How They Work . . .

Simply loosen 6 clamp screws (like removing a wheel from your car) and the dove-tail clamps release the CLAM SHELLS in 3 easy-to-handle sections.

By this means you can easily change from smooth to corrugated rolls, or vice versa—to suit your lumber feeding conditions.

This also solves the problem of feeding icy lumber. When winter comes you can change quickly to corrugated Clam Shells—without disturbing planer-roll-shafts, bearings, gears or sprockets.



CLAM SHELL Quick Change Rolls are Another STETSON-ROSS "FIRST"—more evidence of leadership in the planer matcher field—since 1907.

CLAM SHELL rolls are available for Stetson-Ross Planer models 6-10-A1, 6-12-A1, 6-12 MA1, 6-12-CI, and the 202.

Your inquiry is invited.
No obligation, of course.

STETSON-ROSS MACHINE COMPANY INC
SEATTLE 4, WASHINGTON

Copyright 1955 Stetson-Ross Machine Co., Inc.

Export Division, 301 Clay Street, San Francisco 11, California

Let's Face It!

YOUR OBSOLETE MACHINES ARE YOUR COMPETITOR'S BEST FRIENDS

In the relentless battle for business you're giving your competitors a big assist by hanging on to those sluggard, obsolete machines that are slowing down production. They may have been the pride of the plant in '28 but today they send costs soaring . . . price your product right out of your markets.

Get rid of those old clunkers masquerading as production machines. See how new modern machines can help you produce more profitably. Never before has such a variety of modern, precision machinery been available. Get your machine replacement program started now! Send in this coupon today.

WOODWORKING MACHINERY MANUFACTURERS ASS'N.
1900 ARCH ST., PHILADELPHIA, PA.

Please send me further information. I am interested in the following types of machinery_____

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

Put a profit in your woodworking with MODERN MACHINES

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION

1900 Arch Street, Philadelphia, Pennsylvania

LOVSTED'S DRY KILNS ARE THE MOST EFFICIENT IN OPERATION TODAY

LOVSTED'S DIRECT-FLO DRY KILNS

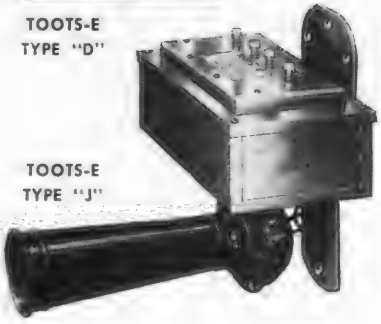
Whatever the specific problem of lumber seasoning, there's a solution in some type of Lovsted "Direct Flo" Kiln. These units, without question, are the most efficient kilns in operation today. They embody such specialized features as reversible circulation with fans positioned to create uniform drying with lowest possible power input per cubic foot of air produced. Look to the engineers of C. M. Lovsted and Co., Inc. to bring your own lumber seasoning to efficient operation.

★ *PROFITS AHEAD WITH LOVSTED!*

TOOTS-E SIGNALS

TOOTS-E
TYPE "D"

TOOTS-E
JUNIOR



TOOTS-E
TYPE "J"

SPECIAL SIGNAL SERVICE FOR 35 YEARS

FOR FOREST AND FACTORY . . .

Serving the signal needs of forest and factory for over thirty-five years, C. M. LOVSTED engineers have developed a full line of Air, Steam, Electric and Vacuum Signal Systems. Their extreme dependability and long life are the result of high standards rigidly maintained. Write today to our Dept. FP-10, outlining your signal problem and we will give you complete technical information that will help you in its solution.

C. M. LOVSTED & CO., Inc.

4000 West Marginal Way
SEATTLE 6, WASHINGTON

2185 Pine
VANCOUVER, B. C.

1001 North Main Street
LOS ANGELES 12, CALIF.

1227 Hopaka Street
HONOLULU 4, T. H.

591 Howard Street
SAN FRANCISCO 5, CALIF

c/o Smith Bell & Co., Ltd.
123 Juan Luna St., P. O. Box 411
MANILA, R. P.

SPECIAL-PURPOSE FURNITURE FASTENERS

and self-fastening devices

These fasteners and other devices are designed either to speed in-plant assembly or to make possible K-D shipment of furniture for assembly by unskilled store personnel or the ultimate purchaser. United-Carr has pioneered in the field of fasteners specially designed for furniture production and, if you have a volume production problem that requires fasteners of a new or special design, United-Carr's engineering staff is at your service.

UPHOLSTERY CLIPS

Applied by hand or with simple hand tool . . . suitable for range of applications, thicknesses and materials . . . firm, positive, grip-ping action . . . do not catch clothing . . . stay out of sight after assembly.

SEAT CLIPS

Attach padded, wood-framed seats to tubular metal frame . . . permit K-D shipment . . . provide quick, dependable fastening at home, store or warehouse. Sizes to fit range of tube diameters and basic frame designs.

HELIX WASHERS

Provide positive anchorage for bolt or threaded rod in metal tubing . . . pull in easily . . . can be removed only with substantial withdrawal force . . . useful in tubing assemblies to attach handles or other tubular components . . . available to fit wide range of thread and tubing sizes.

CAPPED RATCHET PLATES

Decorative hub caps for furniture and wheel goods. Teeth bite into metal rod or axle so rod requires no nuts, threads or cotter pins. Available in range of sizes, light or heavy action, for push-on or hammered assembly . . . aluminum or nickel-plated caps.

PLASTIC BASE SWIVEL GLIDE

Non-corroding, duty-rate feet for wicker or wooden tables or chairs . . . accept legs at angle to floor . . . wide range of plastic colors and metal finishes available in combinations.

DRAWER GLIDES

Deaden noise, ease motion in sliding metal drawers . . . snap into place and stay put in hole stamped out of drawer wall . . . available in nylon or polyethylene material.

SUPER-SILENT SWIVEL GLIDE

Floats on rubber, shock on steel . . . base is completely cushioned from chair or table by rubber cushion. Tenon hold glide in tubular metal legs. Swivel base allows glide to stand flat even though legs slope.

LONG PRONG TEENUT

Has curved prongs that provide twisting action for extra holding power as Teenut is driven into bored hole. Components can be repeatedly assembled and disassembled . . . provides steel threads in wood . . . permits K-D shipment.

SHORT PRONG TEENUT

Can be held in place by brads until final attachment of components by dealer or purchaser. Short prongs prevent turning when longer bolt is tightened.

RECTANGULAR FLANGE TEENUT

Has narrow base for use in limited spaces. Held in place by brads instead of prongs. Specially designed for heavy duty applications.

UNITED-CARR Fastener Corp.

31 Ames St., Cambridge 42, Mass. • *In Canada:* Gage Ave. and Beach Rd., Hamilton, Ontario

MAKERS OF DOT *FASTENERS*

"Our Mereen-Johnson Double Cut-Off Saw

CUTS, DADOS AND TRIMS AS FAST AS WE CAN FEED IT"

Pritchard Superintendent
W. W. "Woody" Loflin

Mereen-Johnson Double Cut-Off Saw processes redwood lumber as fast as these men can handle it.

M-J "300" Is Built For Speed

"The speed, versatility and capacity of our Mereen-Johnson Double Cut-Off Saw is so great that it performs most of the woodworking operations we need in the construction of our line of cooling towers."

Superintendent W. W. Loflin of J. F. Pritchard & Co. of Merced, California, describing the application of their custom-built M-J No. 300 says . . . "Due to the extreme versatility of our machine, it is being used, not only as a double cut-off saw, but also as a tenoner, trim saw and dado machine. It's an extremely efficient, well constructed, high speed piece of machinery.

"Because of the design and construction of the No. 300 it can perform most operations required in our factory. For example, it will cut both ends of a diagonal brace (at any angle) in just one pass. Using an ordinary radial arm cut-off saw, the same type brace requires four cuts and four set ups. The M-J No. 300 cuts these pieces as fast as we can feed them . . . often up to 1000 boards per hour.

"An important advantage of our M-J machine is the fact that it is automatically and electrically controlled, making set-up operations fast, accurate and easy.

"We also use our M-J No. 300 to notch or dado up to 20 slots in one piece of redwood. These notches vary in depth from ½" to 2⅝". For multiple cutting, we can cut one piece of lumber into several pieces of equal or varying lengths in one pass. The machine is also used for trimming bundles of lath and for cutting plywood sheets to exact dimensions.

"Our Mereen-Johnson No. 300 will cut pieces to lengths from one to twenty-one feet long . . . and it performs many other woodworking jobs too."

This top performance machine is custom-built to your application—large or small.
M-J Bulletin No. 300 fully describes every feature. Send for it now!

Mereen-Johnson MACHINE COMPANY

4401 LYNDALE AVENUE NORTH • MINNEAPOLIS 12, MINNESOTA

Siempelkamp

Even this man will no longer be needed...

because this chipboard compregnation plant operates fully automatically once the work-cycle has been set.

The first commercially manufactured chipboard has been fabricated on Siempelkamp presses.

Today, Siempelkamp builds completely designed plants for all fabrication methods.

G. Siempelkamp & Co. . Maschinenfabrik
Krefeld, West Germany

Cable Siempelkampco. . Telex: 0853811 . Telephone: 28676

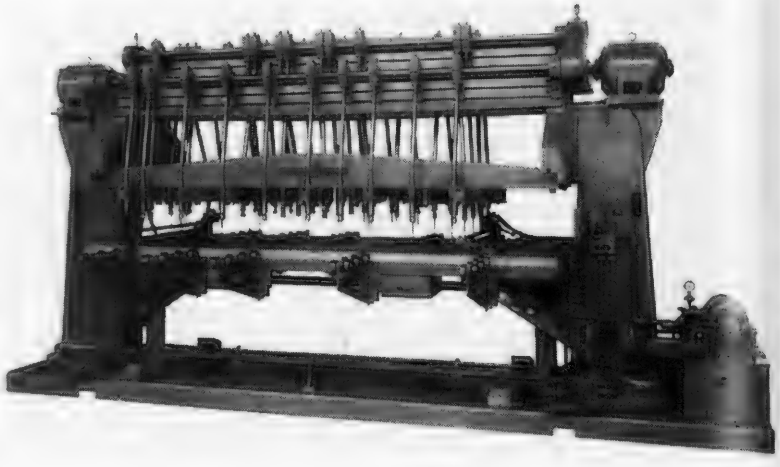
2 NEW MACHINES
solve unusual wood boring requirements

ROOT "2CXH–S4" MULTIPLE BORER
opens new phase in large area boring

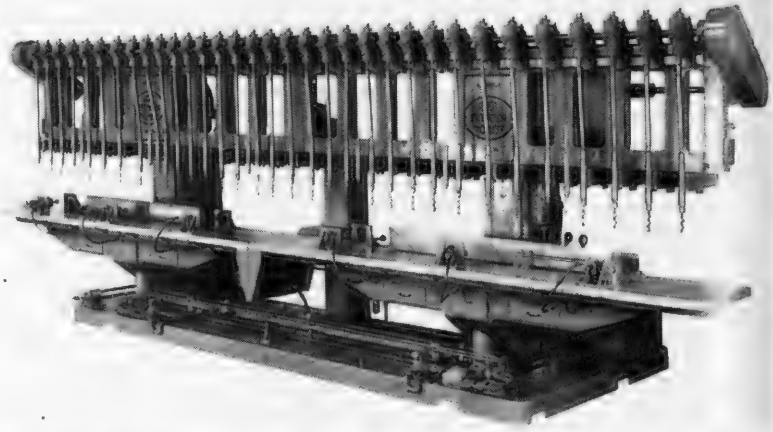
ROOT "CCH" MULTIPLE BORER
3 machines in one—answers production problem of boring stock having wide variances in length

This special 2CXH–S4 Multiple Borer can bore up to 40 holes or more simultaneously in panels up to 10 ft. by 4 ft. Its design offers many engineering "firsts" that make it highly efficient in production boring of large-area work.

It is equipped with adjustable alignment guides and clamping devices, and special in-feed and outfeed roller brackets. Its table is hydraulically operated, with special limit switches that require positive positioning of the work before allowing the boring stroke to start. With slight changes in design this machine can handle panels of any practicable size.



This large CCH Multiple Borer, with hydraulic feed, was built to bore boards and members used in refrigeration cars, some stock being 20' long, other stock less than 10'. To handle all stock efficiently this machine was designed with a divided table. With the table operating as a single unit, all controls and drives work as one large machine for boring the long stock. Then by simple adjustments the machine becomes two smaller independent borers for handling the short stock. It has 33 universally adjustable spindles for in-line or out-of-line boring over a maximum area of 21'–4¼" by 12" cross-line, also many other features.



Write today for complete details on these and other large and unique wood boring machines by Root, also for full information on the standard line of Root production machinery for the woodworking industry — no obligation.

B. M. ROOT CO.
YORK —— PENNA.

FPRS NEWS-DIGEST

Volume VII OCTOBER, 1957 Number 10

President's Column

Board Approves Construction of FPRS Office Building, To Be Completed June, 1958

F. H. KAUFERT

ST. PAUL, MINN., OCT. 1—I am certain that all Society members will be interested to learn that at its fall meeting in Madison, Wisconsin, September 19, the National Executive Board voted to start erection of the proposed new Executive Office Building at the earliest possible date. When this milestone in the progress of the Society is reached, it will mark the culmination of four years of Executive Board and Section activities aimed toward the establishment of a permanent home office.

The driving force behind the fund-raising program, Ray H. Berry, of Burney, Calif., reported that of this date we have received more than $24,000 in funds, cash and pledges in our drive to reach $60,000. This $24,000 dates from May 1, 1957, and does not take into consideration several thousands of dollars of prior contributions; contributions of office equipment; and promises of building materials. In addition, we have a completely paid-up building lot valued in excess of $10,000. Standing behind these funds is an additional cash reserve of $15,000.

After careful consideration of available funds and materials and a revised and current building estimate, the Board authorized the preparation and negotiation of an actual building contract. The Board stated that, "With funds we now have on hand, and our future prospects, we are now in a position to start erection of the new building and have it 'under roof' this winter". It emphasized, however, that efforts will be continued to urge the entire membership and the forest products industry we serve to provide the additional funds that will be needed to complete the building or replenish the reserve, should it be found necessary to use the present reserve. The Building Fund Raising Drive was extended to May 1, 1958.

With the Society's membership expected to approach the 4,000 mark during 1958, and with anticipated expansion of its staff and services in the immediate years, a home office of adequate size and facilities is clearly needed.

During the first ten years of the Society's growth, it was privileged to lease and utilize office space in the U. S. Forest Products Laboratory, and to draw upon its outstanding informational facilities. With the continued growth, both of the Laboratory and of the Society, it became apparent in recent years that the Society would have to seek larger quarters elsewhere. The present rented quarters are recognized as inadequate and undesirable location-wise, but they were contracted for on a temporary basis to take care of immediate needs.

It is a tribute to the vision of earlier National Executive Boards who foresaw this need and acted to bring the Building Program to its present status back in 1953. In 1954, we purchased an outstanding building lot, which it is doubtful would be available today in view of business expansion in Madison. The location of this lot and our home office building when completed will bring the Society to the daily attention of the stream of visitors to the Forest Products Laboratory, and greatly benefit us.

In 1954, we also commissioned our present President-Elect, Mr. W. Jeter Eason of Nickey Brothers, Memphis, Tenn., and president of a leading architectural firm, to design our future office. The building that will be erected in 1958 will be an expression of the progress which is being made today by the forest products industries through research. It will represent many of the newest advancements in forest products.

Present plans call for a contract to be signed and basement construction be started this fall. The laminated beams and arches will be put in place early in 1958, and efforts will be made to have the building as nearly complete as possible at the time of our 12th National Meeting in Madison, June 22–27, 1958.

Members are urged to understand that while we are about to put the building "under roof" at this time, an additional $20,000 to $25,000 of contributions will be necessary so that the Society may be able to own this building outright and that its reserve, which has been earned over a period of ten years, will be kept intact or be replenished and if possible strengthened. Therefore, members and companies who have not already done so are being asked to make individual or company donations, and those who have donated are asked to make added donations to complete the job. We are close to the goal that has been the objective of all past Executive Boards. With some added effort we can achieve our objective and build an even stronger and sounder Forest Products Research Society.

In closing, let me say that the Executive Board acted only after careful consideration of every aspect of this problem. In taking the important action we did at the September 19, Madison meeting, we were acting for you, the members and supporters of the Society. We hope that all of you share our enthusiasm for the progress made and will redouble your efforts to bring this dream to reality.

FRANK H. KAUFERT, *President*

Inland Empire Holds Largest Meeting in Its History

More than 60 persons attended the Inland Empire Section fall meeting, September 27–28, at Omak, Wash., Herbert B. McKean, section chairman reported recently.

A Friday luncheon was held at the James J. Hill hotel with R. L. McNett, Biles–Coleman general manager, as toastmaster and E. S. Kotok, chief, forest utilization service Ogden, Utah, speaking on the Wyssen Sky Line logging systems. George Gray, Omak chamber of commerce president welcomed the visitors.

Highlights of Friday afternoon were the tours of the Biles–Coleman Lumber Co. operations, including the sawmill and logging divisions. Over eighty persons attended the Friday evening banquet, at which T. S. Veazey reported on the National FPRS meeting.

A technical session was featured on Saturday morning and included the following speakers: Milton H. Mater, Mater Engineering Co.; H. R. Swanson, Dominion Bridge Co., Ltd.; Julius W. Mann and George Russell, Mann–Russell Electronics; and Paul Watts, Paul Watts, Inc.

Florida–Georgia–Alabama to Hold Meeting December 5–6

"Progress Reports on Research and Development in Wood Utilization" will be the theme of the Florida–Georgia-Alabama Section meeting, December 5–6. Headquarters for the meeting will be the Casa Linda Hotel, Daytona Beach, Fla., announced Ralph Peter, secretary–treasurer of the section.

Oregon Laboratory Short Course Postponed

The annual six-day short course in lumber seasoning usually held in December at the Oregon Forest Products Lab. in Corvallis, has been postponed until January or February, J. B. Grantham, managing director of the laboratory announced recently. Exact date for the course will be announced later.

Postponement was made necessary by moving of the Laboratory's equipment and offices to new quarters at the Oregon Forest Research Center, just west of Corvallis. It was announced that drying facilities were to be completely rebuilt and would include two small kilns built of aluminum, each capable of holding about a thousand board feet of 8-foot lumber. One of the kilns will have flexible design to permit studies in high-temperature drying.

Softwood Lumber Grading Topic of Short Course

Softwood lumber grading and related subjects will be the topic of a five-day short course at Michigan State University, December 2–6. Sessions will be held at the Kellogg Center for Continuing Education.

Aimed at creating greater familiarity with various species, grades and uses, the course has the second goal of enabling personnel to buy, sell or handle lumber, make recommendations and discuss customer's problems in the use and care of wood products.

The course is sponsored by the Dept. of Forest Products and the Cooperative Extension Service of Michigan State University in cooperation with the Southern Pine Inspection Bureau, The Western Pine Assoc., and the West Coast Lumber Inspection Bureau.

The first 1 to 1½ days will be taken up with the properties of wood, use and abuse of wood, common misconceptions, defects, seasoning and care of wood, preservative treatment, and American Lumber Standards. Staff of the Dept. of Forest Products will present this part. On the remaining 3½ to 4 days, representatives of the three associations will illustrate grades, clarify provisions of the rule books, and explain functions of the Associations.

Registration fee is $25 per person, not including room reservations or banquet tickets. Up to 100 enrollees will be accepted. Information can be obtained by writing to the Softwood Lumber Grading Course, Continuing Education Service, Michigan State University, East Lansing, Mich.

Dry Kiln Short Course Announced

A short course in kiln operation, will be held December 2–7, at the University of California Forest Products Laboratory. The five and a half day course will consist of lectures, demonstrations on dry-kiln mechanics, kiln operation, quality control in drying, wood moisture relations and dry-kiln schedules. Operation of the laboratory's dry kiln will be featured.

The teaching staff will include F. E. Dickinson, director of the laboratory; R. A. Cockrell, prof. of forestry at the University; E. L. Ellwood, associate wood technologist at the laboratory; A. P. Schniewind, specialist at the laboratory; and Harvey Smith of the California Forest and Range Experiment Sta. of the U. S. Forest Service.

Fee for the course will be $75. Inquiries concerning registration should be sent to University Extension, University of Calif., Berkeley 4, Calif.

Sixth Annual AITC Meeting Scheduled for January

"Sales—Today and Tomorrow" will be the theme of the sixth annual meeting, January 20–24, 1958 of the American Institute of Timber Construction, according to Val Gardner, president of the Institute.

Business session programs are being developed around the theme for the middle days of the meeting. AITC directors will meet on the first and last days of the session. Directing plans for the meeting are I. A. Jacobson, AITC vice-president, and Richard Jacobson, general chairman of the annual meeting committee.

Forest Insect Research Scheduled at Oregon State College Lab.

A $35,000 forest insect laboratory has been completed at Oregon State College for research on forest pests. The major phase of the work will be the testing of insecticides to determine which are most effective and practical to use against various insects.

Tied in with the testing will be basic research on insect biology, behavior and activities. Entomologists of the Oregon State Board of Forestry are cooperating in the research. The Douglas-fir beetle, which has infested some 6 million acres in 1955 in the Northwest, will be one of the insects studied.

The project is sponsored by the Northwest Forest Pest Action council, the Oregon State Board of Forestry, and the Pacific Northwest Forest and Range Experiment Station, Portland, in cooperation with the college. A grant of $3800 was received recently from the Foundation for American Resource Management, San Francisco, to help support the research.

Wooden Box Industry Personality Dies at 67

Clough D. Hudson, 67 years old and executive vice president of the National Wooden Box Assoc. for 24 years, died of a heart attack recently at a Washington D. C. hospital.

Born in Tekamah, Neb., in 1890, Mr. Hudson held a B. A. and M. A. degree. In 1933 he accepted the executive vice presidency of National Wooden Box Assoc. For the past 12 years he had served as president of the American Box Shook Export Assoc., with offices in San Francisco and Washington.

A prominent personality in the wooden box industry, Mr. Hudson was also active in civic affairs.

Austin State College Receives Scholarship from Foundation

A $500 forestry scholarship was established recently at S. F. Austin State College, Nacogdoches, Texas, by E. L. Kurth, through the Southland Paper Mill Foundation, of which he is head. According to Mr. Kurth, the purpose of the scholarship is to help train professional foresters dedicated to the task of perpetuating the timber supply of East Texas.

Dr. Arne K. Kemp, head of the S. F. Austin State College Forestry department, said the scholarship will be awarded to a qualified forest management student on the basis of academic aptitude, professional promise, leadership, character, and financial need.

Mr. Kurth is president of Southland Paper Mills, the first paper mill to make newsprint from southern pine.

Large Capacity Planer and Matcher to Be Built

The building of a new planer and matcher for the Georgia–Pacific Corp., believed to have the greatest capacity for planing lumber ever produced, has been announced recently by the S. A. Woods Machine Co., Boston, Mass.

It is reported that the feed rolls will be built with a diameter to produce a maximum feed rate of 1200 lineal feet per minute. The machine will be equipped with a water-cooled guide to offset increased temperature caused by the accelerated rate of production.

Mid-South Firm Elected to Active Membership in AITC

Ronald A. Coco, Inc., Baton Rouge, La., has been elected to active membership in the American Institute of Timber Construction, according to Frank J. Hanrahan, executive vice-president of the Institute.

First firm in the mid-South to qualify for active membership in the organization, it manufactures glued laminated wood beams, arches and roof trusses. The firm has been a long-time member of the Southern Pine Association and the SP inspection Bureau. Ronald A. Coco, president, is a member of SPA's trade promotion and research committees.

Graco Plant Opens Soon

A new $1,500,000 Graco Flakeboard Plant, Waverly, Va., will be ready for full production in November, according to Elmon T. Gray, president, Gray Products Co., Inc. The plant is expected to produce 25 million sq. ft. a year on a ¾ inch basis.

The plant will utilize a Miller–Hofft engineered flakeboard system, and most of the first year's production will be in 5 x 10 ft. sheets of ½- to 1 3/16-inch homogenous board. A 3-ply board of homogenous core with top and bottom layers of "fines" will also be manufactured.

Lumber Distributors Urge Unified National Promotional Campaign

A group representing 39 of the nation's leading lumber wholesalers and producers met in Chicago October 28, to form and elect an interim steering committee for the National Lumber Council for Marketing.

Recognizing the seriousness of the current market situation facing the lumber and wood products industry, the organization believes that the combined industry needs to inaugurate a unified and concerted promotion and marketing effort if it hopes to make secure and enlarge markets now being sought by competing non-wood materials.

A three-man subcommittee composed of Walter E. Morgan, Morgan Lumber Sales, Columbus, Ohio, and chairman of the interim committee; Thomas DeWeese, A. DeWeese Lumber Co., Philadelphia, Mississippi; and Lawrence J. Fitzpatrick, Madison, Wisconsin, was named to present the results of the committee's deliberations to the annual meeting of the National Lumber Manufacturers Association in Washington, D. C., November 11 to 13.

In a telegram sent to NLMA president Walter M. Leuthold, interim Council chairman Morgan stated, "A representative group of lumber wholesalers, commission men and producers met in Chicago at the second meeting of the committee of 'inquiring minds' now known as the National Lumber Council for Marketing and made a further study of the conditions of our market. This group unanimously resolved to express to you the hope that the National Lumber Manufacturers Association will at their coming meeting inaugurate a substantial advertising and or promotional program for lumber and wood products. We wish to lend our aid. It is felt we could offer practical suggestions for providing both financial and manpower assistance from a vast number of lumber men who may or may not now be identified with established associations on a national, state and local level."

Companies and members of the press represented at the Chicago meeting included: Allison Lumber Co., Bellamy, Ala.; American Lumberman Magazine, Chicago; Bradley Lumber Co., Warren, Ark.; Brown and Bryan Lumber Co., New York; Leo Burnett Advertising, Chicago; J. Philip Boyd and Co., Chicago; Dealers Warehouse Supply Co., Arlington, Va.; A. DeWeese Lumber Co., Philadelphia, Miss.; J. J. Fitzpatrick Lumber Co., Madison, Wis.; W. S. Fox & Sons, Pine Bluff, Ark.; D. B. Frampton & Co., Columbus, O.; A. F. Gehner Lumber Co., St. Louis; Edward Hines Lumber Co., Chicago; Huss Lumber Co., Chicago; E. W. Kettlety Lumber Co., Chicago; Life Magazine, Chicago; Morgan Lumber Sales Co., Columbus, O.; Natt–Wolf Lumber Co., Chicago; Intermountain Lumber Co., Missoula, Mont.; National Building Materials Assoc., Chicago; J. B. O'Meara Co., Minneapolis; Pacific Lumber Co., Chicago; Pack River Tree Farm Products, Spokane, Wash.; Ponderosa Pine Woodwork Assoc., Chicago; S. C. Poore and Co., Chicago; Protection Products Mfg. Co., Kalamazoo, Mich.; Shehan Gary and Co., St. Louis, Mo.; Somerville–McGinn Lumber Co., Park Ridge, Ill.; Southwest Lumber Mills, Chicago; Tri-State Lumber and Shingle Co., Kansas City, Mo.; Weyerhaeuser Sales Co., St. Paul; Martin Wiegand, Inc., Washington, D. C.; Wood and Wood Products Magazine, Chicago; Robert Clegg, Consultant, Chicago; Ben Springer, Milwaukee, Wis.; W. B. Thomas, Portland, Indiana.

NEW PUBLICATIONS

An Inexpensive Method for Measuring Charcoal Kiln Temperature. R. Peter. Describes tests made in experimental 7-cord charcoal kiln located at Athens, Ga., using an inexpensive standard brand D.C. microameter to measure kiln temperatures. Station Paper No. 73, Southeastern Forest Experiment Station, Asheville, N. C.

Common Browse Plants of the Georgia Coastal Plain, Their Chemical Composition and Contribution to Cattle Diet. L. K. Halls, F. E. Knox, and V. A. Lazar. Consolidates available information on several important browse plants of the Georgia coastal plain so that their value and over-all contribution to cattle feed can be more fully assessed and compared to other kinds of forage. Station Paper No. 75, Southeastern Forest Experiment Station, Asheville, N. C.

Use of Beech in Rough Construction on the Farm. W. T. Nearn. Beech Utilization Series No. 14, Northeastern Forest Experiment Station, 102 Motors Ave., Upper Darby, Pa.

Marketing Information Available to Forest Owners. Presents a summary of a survey made by the Forest Industries Council of forest products marketing activities throughout the U. S. Published by Forest Industries Council, Room 1712, 220 East 42nd St., New York 17, N. Y.

Manufacture and Uses of Hardwoods in British Columbia. R. W. Wellwood. Contains information on the production, manufacture, properties and uses of British Columbia hardwoods.

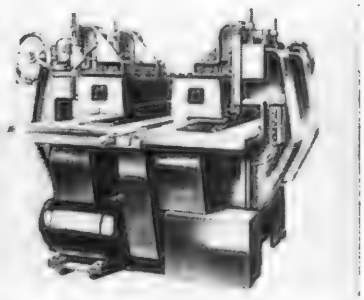
Nails and Spikes in Creosote-Pressure-Treated Southern Pine Poles and Timbers. E. G. Stern. Virginia Polytechnic Institute Wood Research Laboratory, Blacksburg, Va.

Charcoal Production in the United States. Discusses production, markets, prices, kilns and wood consumption. Available from the Division of Forest Economics Research, U. S. Dept. of Agriculture Forest Service, Washington, D. C.

The Timber Supply Situation in Georgia. R. W. Larson. Forest Resource Report No. 12. Available for 55¢ from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

(continued on page 102-A)

NEW PRODUCTS—LITERATURE



New Ripsaw Design

Yates–American Machine Co. has announced the introduction of a new ripsaw design based on the principle of a double precision chain feed.

"Twinrip" has dual cutting action, normal feed at both ends of the machine, with feed rates up to 300 fpm for each chain feed. Each unit accommodates panels up to 23 inches wide. Bulletin describing the Twinrip is available from Yates–American Machine Co., Beloit, Wis.

Veneer Knives

A four-page bulletin on SWWCo Veneer knives is now available. Knives for the veneer and plywood industries are described and illustrated. Available from the Simonds Worden White Co., 1101 Negley Place, Dayton 7, Ohio.

(continued on page 103-A)

EMPLOYMENT SERVICE

The FPRS Employment Service is operated without charge as a service to members. Companies or institutions with positions to be filled or individuals seeking employment may participate in this program by inserting a free ad in two consecutive issues of the FOREST PRODUCTS JOURNAL. Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E–294—Sales engineer for well-established firm in the forest products industry needed by northwest concern. Product to be serviced is particle board. National travel to service accounts and contact customers. College training desired, preferably in forest products. (Oct.)

E–295—Research Technician desired, preferably wood technologist with experience in plastic overlays and wood finishes as well as wood products, plywood and adhesives. Primarily laboratory work in product development. Pacific Northwest. (Oct.)

E–296—Chemist or chemical engineer desired for insulation fiber board research and development work in recently established Midwest research center of large insulation board manufacturer. Background in wood utilization for fiber products desired. Good opportunity. (Nov.)

E–298—Wood technologist with good chemistry background needed for expanding research division of Eastern wood preservative manufacturing concern. Duties involve research, product development and some technical service. Initiative and creative ability desired. Reply giving academic and industrial experience and salary desired. (Nov.)

E–299—Recent graduate desired, with knowledge of lumber and wood products. Learn wholesale lumber business. Must be aggressive and interested in selling lumber specialty wood products, and particle board. Moderate salary to start. Located in California. (Nov.)

Employment Wanted

No. 440—Graduate in Forest Products seeks position in production management. Experience in manufacture of industrial products (boxes, crates, reels, and pallets) including supervision, job planning, container design, inspection and sales. Age 29. Prefers Southern location. (Oct.)

No. 443—Position desired in forest products sales, distribution, or production. Graduate of Penn. State University with a B. S. in Forestry. 24 years of age and just completed two years of duty in the Army. (Oct.)

No. 444—Experienced factory superintendent desires management or sales opportunity. Holds masters degree in forestry from the University of Michigan. Familiar with all phases of factory management including production control, costs, purchasing, labor relations. Has worked closely with sales and design. Recent tests show high sales and managerial talents. Age 33, married. (Nov.)

No. 445—Position wanted in analytical research or development in any phase of forest utilization, either manufacturing or merchandising. Holds a B. S. in wood utilization and an M. S. in wood technology. Experienced in basic wood research, wood preservation, sales, development engineering in hardboard, lumber manufacturing and drying, and as a plant engineer at integrated lumber operation. Age 33. (Nov.)

No. 447—Position desired as chief engineer or research engineer. Age 29, holds B. A. in Chemistry and Master's degree in Wood Technology. Five years experience in paper, furniture, chemical research and automation. Rocky Mountain or South American location desired. (Nov.)

WOODWORKING PRODUCTION MANAGER

Growing upstate New York firm has an excellent opportunity for a man with an engineering education and a technical woodworking production background.

We want a man who has proven his abilities by performance, who is aggressive and wants an opportunity that will increase his income and position.

This firm has several plants with several hundred employees making diversified wood products. This is not a superintendents job but requires similar experience in the background. We are looking for an Executive who has vision as well as experience. A man capable of developing and executing production plans, controls and standards, who can be a works manager supervising personnel, methods, costs, equipment needs, etc.

If this information challenges you—you may be our man. We invite you to tell us about yourself. All replies will be held in strict confidence.

Send replies to:
E-297, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
P. O. Box 2010, University Station
Madison 5, Wisconsin

OPPORTUNITIES IN APPLIED RESEARCH

Stimulating and challenging positions are opening up in our expanding Research and Development Department in Cloquet, Minnesota. At this time there is a responsible position open in the Applied Science Area:

Research Physicist—Engineering physicist or research engineer with graduate training having background and interest applicable to fundamental mechanical properties of materials, heat transfer, moisture transfer or sound aborption and sound isolation characteristics of fibrous and porous materials. Three years industrial experience desired.

Salary commensurate with education and experience.

Applicants should submit a complete resumé of personal data, educational background, work experiences and references to:

Development Department
WOOD CONVERSION COMPANY
Cloquet, Minnesota

Eleventh National Meeting Attended by 672

REGISTRATION takes place for the meeting.

GENERAL CHAIRMAN, Charlie Lockard addresses the membership at the opening session of the 1957 National Meeting.

THE FPRS ELEVENTH NATIONAL MEETING, June 23–28, at the Statler Hotel, Buffalo, New York, "has been characterized by many as 'successful' ", according to Charles R. Lockard, general chairman of the meeting.

Mr. Lockard went on to say, in reporting on the meeting, that "Attendance was good, and the technical programs were excellent and well received. Major speakers were outstanding, and the general and ladies social events were pleasant."

Attendance Tops 600

Official attendance at the Eleventh National Meeting was 672, of which 126 were ladies. Of the men, 427 were members and 119 were non-members. An additional 78 non-registered attendees raised the total estimated attendance to 750.

Registration began Sunday afternoon, June 23, at 1 P.M., and was capably handled by the Buffalo Convention Bureau. The registration fee was $8 for FPRS members, $12 for non-members, and included admission to all technical sessions, committee meetings, plant tours, the Paul Bunyan Smorgasbord and Tour, as well as a copy of abstracts of technical papers. Ladies registration fee was $5. Sunday afternoon several committee meetings were held. These included the National Board Meeting, the Northeastern Board Meeting, and meetings of the Employment Committee, the Industry-Education Committee, and the Publications Committee.

Traditional Host Hour

The social activities began with the traditional Host Hour on Sunday evening, sponsored by the Northeast and Eastern Canadian host Sections. The informal get-acquainted reception was held from 7:00 to 9:00 P. M., in the Maple Leaf Room.

Suppliers Exhibit

The 65-booth Suppliers Exhibit was open every day from 9 A. M. to 6 P. M., except for Wednesday afternoon. (See page 00-A for complete description.)

Principal Address and Awards Featured at General Opening Session

Dr. Lincoln R. Thiesmeyer, president, Paper and Pulp Research Institute of Canada, presented a paper entitled "Everything, Including the Smell" at the opening general session of the meeting. Dr. Thiesmeyer addressed the session of about 250 persons in the Ballroom of the Statler Hotel. (Read Dr. Thiesmeyer's address elsewhere in this issue.)

The Rev. Frank Reed, editor, N. E. Logger, opened the session with an invocation. The Hon. W. B. Lawless, president of the City Council, welcomed FPRS to Buffalo. Greetings were extended from Host Sections by D. K. Saunders, Chrm., Northeast Section, and G. S. Billington, 2nd Vice-Chrm., Eastern Canadian Section. C. R. Lockard, General Chrm., presented a synopsis of the meeting, and R. H. Bescher, FPRS president, officially opened the meeting.

Annual Northeast Section Awards were presented by Dr. Eric Anderson, Chrm. of the Student Award Committee, to William T. Heise, $75; Charles F. Bowers, $50; and Robert T. Ward, $25. The awards were given for excellence in student academic work and leadership qualities.

SUNDAY EVENING RECEPTION started week long social activities, with Northeast and Eastern Canadian Sections as hosts.

SESSION I—GLUES AND GLUING

SESSION II—WOOD MACHINING

SESSION III—VENEER AND PLYWOOD

SESSION IV—WOOD FINISHING

SESSION V—LOGGING

SESSION VI—WOOD COMPOSITION BOARD

SESSION VII—WOOD PRESERVATION

SESSION VIII—CHEMICAL UTILIZATION (LIGNIN)

AWARD OF MERIT citations were presented by V. C. Hogren, Hitchcock Publishing Co., to E. F. Anderson, Monsanto Chemical Co.; W. Henrich, Architectural Woodwork Institute; E. S. Johnson, N. C. State College; C. A. Luce, West Coast Lumbermens Assoc.; A. E. Oviatt, Timber Structures, Inc.; and (not shown) R. W. Pettersen, St. Paul and Tacoma Lumber Co.

WOOD AWARD winner R. L. Youngs is congratulated by J. F. Koellisch, Wood & Wood Products magazine. Looking on are A. J. Panshin, second place winner C. W. McMillin, and H. C. Moser, chairman of judges.

8th Annual Wood Awards

The 8th Annual Wood Awards, sponsored by WOOD AND WOOD PRODUCTS magazine in cooperation with the FPRS were presented at the opening session. J. F. Koellisch, editor and manager of WOOD AND WOOD PRODUCTS presented the awards to Robert L. Youngs, U. S. Forest Products Laboratory, and Charles W. McMillin, Ann Arbor, Mich. The awards are given for outstanding research by graduate students in forestry and wood technology.

Youngs won $350 and a certificate for his paper on "Mechanical Properties of Red Oak as Related to Drying", based on a dissertation which he recently submitted as a candidate for a Ph.D. in Forestry at Yale University.

"The Relation of Mechanical Properties of Wood and Nosebar Pressure in the Production of Veneer" was the title of McMillin's paper. He received $150 and a certificate.

A total of 15 entries were received from eight colleges and universities in this year's competition. The following schools were represented: University of Michigan, Yale University, University of British Columbia, University of Toronto, Iowa State College, State University of New York College of Forestry, Duke University, and the University of Washington.

Award of Merit Citations

Award of Merit citations for outstanding service and contributions to the promotion of wood and wood utilization were presented at the general session by V. C. Hogren, Hitchcock Publishing Co., publishers of WOOD WORKING DIGEST. This year's recipients were: Monsanto Chemical Co., E. F. Anderson; Architectural Woodwork Institute, W. Henrich; N. C. State College, E. S. Johnson; West Coast Lumbermen's Assoc., C. A. Luce;

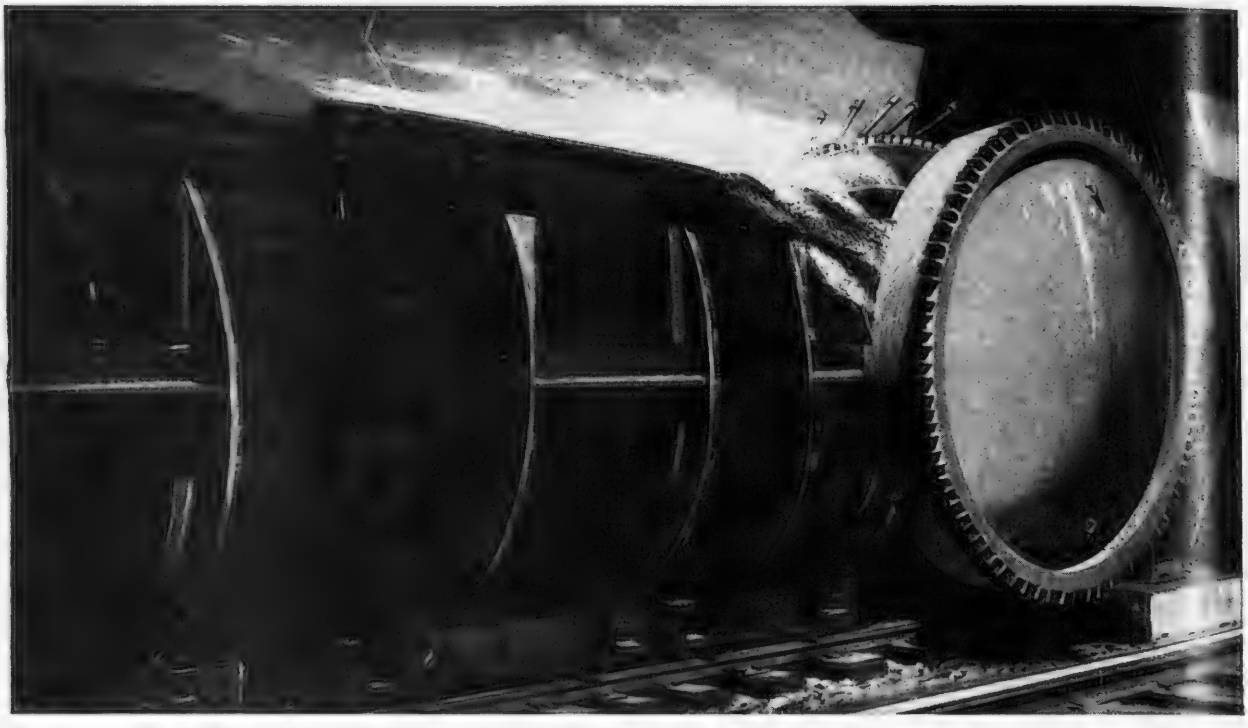
SESSION IX—WOOD DRYING

SESSION X—LUMBER MANUFACTURING

SESSION XI—CHEMICAL UTILIZATION (GENERAL)

SESSION XII—QUALITY CONTROL

Why it pays to PRESSURE-TREAT with CREOSOTE



It's available anywhere—fast!

With creosote treatments . . . supply is never a problem. Qualified pressure-treating plants are located in *every* section of the United States. Service is fast, quality assured.

OTHER IMPORTANT ADVANTAGES:

Depth of penetration can be visibly checked: No guess-work, no involved analyses with pressure-creosoting. You can actually *see* depth of penetration in any cross-section.

Chemical stability: Creosote does not decompose or react chemically with soil-water to become soluble under any service conditions—even in piling that has been submerged for many years.

Longest proved protection: Creosote is the *only* time-proved preservative. There are numerous cases of pressure-creosoted wood that has been in service *well over 50 years!*

Multiple toxicity: Because creosote consists of many toxic components, wood-destroying insects and fungi and marine borers cannot build up an immunity.

Retards checking and brooming: Creosote remains in the wood, fights moisture, helps prevent checking and brooming.

Resists destruction by grass and brush fires: Whereas certain preservatives using light petroleum solvents can actually be fire hazards, creosote protects wood from most small fires.

Dollar for dollar your best buy is Creosote—the only time-proved preservative! Add up all of creosote's advantages and it's easy to see that today—as always—pressure-treatment with Coal-Tar Creosote gives *more* protection per dollar than any other type of preservative available. For more detailed information, write for our 16-page booklet. It's free.

Barrett®

BARRETT DIVISION

Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y.

OVER 100 YEARS OF LEADERSHIP

Timber Structures, Inc., A. E. Oviatt; and St. Paul and Tacoma Lumber Co., R. W. Pettersen.

Foy Speaks At Official Luncheon

Principal speaker at the Official Luncheon was Fred C. Foy, president, Koppers Co. Mr. Foy addressed the 380 guests on "The Challenge of Forest Products Research." (See Mr. Foy's article in this issue.) Outgoing FPRS President Bescher was presented with a camera flash outfit as a token of the Society's appreciation by incoming President Kaufert. The Rev. Reavis Sproull gave the invocation. Mr. Donald Grymes, vice-president, Koppers Co., was among those present at the luncheon.

FPRS Party

Highlighting Tuesday evening was the Official FPRS Party and Banquet, attended by 381 persons in the Ballroom, and presided over by toastmaster Charles R. Lockard. Entertainment was provided by a Buffalo civic choral group, and accordion and other acts.

Paul Bunyan "Smorgasbord"

The entertainment highlight of the meeting was the Paul Bunyan "Smorgasbord" Supper held at Brock Monument Park, Ontario, Canada, located on the shores of the Niagara River. On the way back to Buffalo, the 575 attendees viewed Niagara Falls with 1,440,000 candlepower of light reflected to penetrate the heavy mists. Vari-colored screens in front of the searchlights caused the Falls to take on the appearance of a rainbow.

Paul Bunyan Sponsors

The wood industry suppliers who were hosts to registrants and their families included:

American Cyanamid Co., New York
American Manufacturing Co., Tacoma, Wash.
American–Marietta Co., Chicago, Ill.

MORE THAN 500 attended the Paul Bunyon "Smorgasbord" supper at Brock Monument Park, Canada.

Bahnson Co., Winston-Salem, N. C.
Barrett Division, Allied Chemical & Dye Corp., New York
Bauer Bros. Co., Springfield, Ohio
Behr-Manning Co., Inc., Troy, N. Y.
Black Brothers Co., Inc., Mendota, Ill.
Borden Co., New York
Carborundum Co., Niagara Falls, N. Y.
Catalin Corp. of America, New York
Clark Equipment Co., Battle Creek, Mich.
Cleworth Publishing Co., Industrial Woodworking, Cos Cob, Conn.
Coe Manufacturing Co., Painesville, Ohio
Peter Cooper Corps., Gowanda, N. Y.
Delta Power Tool Division, Rock-Well Mfg. Co., Pittsburgh, Pa.
Dow Chemical Co., Midland, Mich.
Durez Plastics Division, Hooker Electrochemical Co., North Tonawanda, N. Y.
Firth Sterling, Inc., Pittsburgh 30, Pa.
Fjellman-American, Inc., Joliet, Ill.
General Electric Co., Metallurgical Products Dept., Detroit, Mich.
Hitchcock Publishing Co., Wood Working Digest, Wheaton, Ill.
Kennametal, Inc., Latrobe, Pa.
Koppers Co., Pittsburgh, Pa.
Lilly Co., High Point, N. C.
Masonite Corp., Chicago, Ill.
Mattison-Greenlee Service Corp., Rockford, Ill.
Merritt-Solem Division, Solem Machine Co., Lockport, N. Y.
Moore Dry Kiln Co., Jacksonville, Fla., North Portland, Ore., Brampton, Ont., and Vancouver, B. C.
National Casein Co., Riverton, N. J.
National Starch Products, Inc., New York
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.

(Continued on page 65-A)

TOASTMASTER Charlie Lockard, with committee members and their wives, presides at the official banquet.

Onsrud Machine Works, Inc.

Mattison–Greenlee Service Corp.

General Electric Co.

The Bahnson Co.

Oliver Machinery Co.

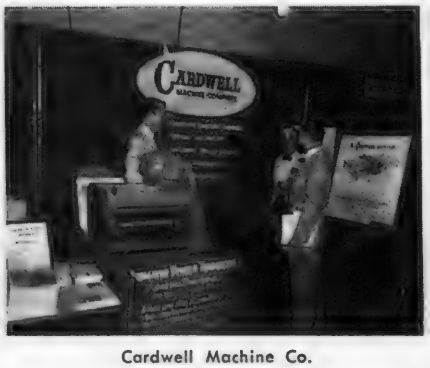
Miller Hofft, Inc.

McCulloch Motors Corp.

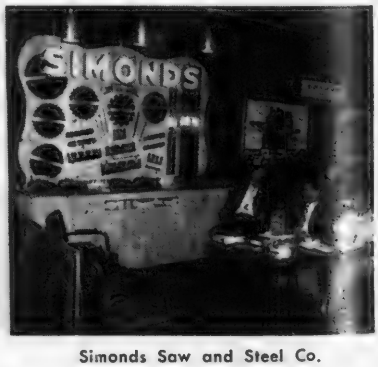
Marcoloy, Inc.

Industron Corp.

Price & Rutzebeck.



Cardwell Machine Co.



Simonds Saw and Steel Co.

Powerline Sales, Inc.

Senco Products Inc.

Timber Engineering Co.

56 Firms Show Products at FPRS Suppliers' Exhibit

FIFTY-SIX FIRMS AND EDUCATIONAL ORGANIZATIONS occupied the sixty-five booth FPRS Suppliers' Exhibit held in connection with the Eleventh National Meeting. The exhibits were held on the mezzanine of the Hotel Statler, adjacent to the Society's technical meetings.

Exhibit hours were from 9 A. M. to 6 P. M. Monday through Thursday with the exception of Wednesday afternoon, when a majority of registrants attended the Paul Bunyan Smorgasbord.

While there were 546 official meeting registrants who had the opportunity to visit the exhibit, it is estimated that 50 to 100 additional persons from nearby forest products industries also visited the exhibit, to bring the total attendance in the neighborhood of 600. Russell C. Deckert was Exhibit Chairman this year.

FPRS 1957 Exhibitors

A list of the exhibitors along with their principal exhibits through illustration, model or actual machinery, follows:

Adamson United Co., Akron, Ohio—Booth 23. Exhibited particle board extrusion machine and process.

Armstrong Machine Works, Three Rivers, Mich.—Booth 40. Exhibited steam traps.

The Bahnson Co., Winston-Salem, N. C. —Booth 27. Humidifier used extensively for laboratories, storage areas, and rooms with low ceiling heights. Illustrated material on complete line of industrial humidification equipment.

Bauer Bros. Co., Springfield, Ohio—Booth 7. Model of "Bauer-bale" system of preparing pulp for shipment, including "fluff-dry" treatment of pulp and baling it.

Cardwell Machine Co., Richmond, Va. —Booth 20. Tangential separators and allied equipment.

Cleworth Publishing Co., Cos Cob, Conn.—Booth 48. Industrial Woodworking magazine.

Peter Cooper Corps., Gowanda, N. Y. —Boooth 3. Applications of animal, liquid, and resin adhesives in varied furniture and woodworking operations.

Columbia Engineering Co., Corvallis, Ore. and Vancouver, B. C.—Booth 81. Consulting industrial engineers.

Deluxe Saw and Tool Co., Louisville, Ky.—Booth 26. Carbide-tipped cutting tools and sawblades.

Dryalator Division, Orr & Sembower, Inc., Reading, Pa.—Booth 14. Wood drying systems.

Ekstrom, Carlson & Co., Rockford, Ill.—Booth 46. Woodworking machinery.

Fastener Corp., Chicago, Ill.—Booth 10. Automatic tackers, staplers and staples. Air-operated bench tacker manufactured in single units with range of stapling heads.

Fjellman American, Inc., Joliet, Ill.—Booth 79. Working model of a new particle board process.

General Electric Co., Metallurgical Products Dept., Detroit, Mich.—Booth 31. Solid cemented carbide planer knives produced in lengths up to 72 inches.

The Heil Co., Milwaukee, Wis. —Booth 32. Equipment for dehydrating wide variety of wood by-products ranging from sawdust, chips, flakes, to rather coarsely hogged veneer waste.

Hitchcock Publishing Co., Wheaton, Ill.—Booth 21. Wood Working Digest magazine.

Industron Corp., Newton Highlands, Mass.—Booth 4. High frequency heating equipment.

International Harvester Corp., Chicago, Ill.—Booth 8. Logging equipment.

Kennametal, Inc., Latrobe, Pa.—Booth 36. Carbide bits, knives, tips, and a variety of materials machined by carbide.

Lemmon & Snoap, Grand Rapids, Mich.—Booth 52. New carbide-tipped saw blade, known as "flying cutter". There are no gullets between teeth.

Hugh C. MacLean Publications Ltd., Don Mills, Ontario, Can.—Booth 86. Canadian Woodworker magazine.

Marcoloy, Inc., Springdale, Conn.—Booth 39. Carbide tool and cutter-head equipment in all phases applying to woodworking industry. Exhibitions of raw materials and processing of tungsten carbide from ore to the finished tool.

Masonite Corp., Chicago, Ill.—Booth 5. Five types of industrial hardboard products; perforated, presealed, and laminated hardboards; examples of hollow core panel construction; and display of various finishes applied to Masonite Presdwoods.

Mater Engineering, Corvallis, Ore.—Booth 75. Mill modernization and automating operations.

Mattison-Greenlee Service Corp., Rockford, Ill.—Booth 12. Woodworking machinery and tools.

McCulloch Motors Corp., Los Angeles, Calif.—Booth 43. Chain saws.

Michigan State University, East Lansing, Mich.—Booth 82.

University of Michigan, Ann Arbor, Mich.—Booth 77.

Miller-Hofft, Inc., Richmond, Va.—Booth 22. Model particle board plant.

Moore Dry Kiln Co., Jacksonville, Fla., North Portland, Ore., Brampton, Ont., and Vancouver, B. C.—Booth 41. Moore chain-arm stacker and prefab kiln building.

National Casein of New Jersey, Riverton, N. J.—Booth 45. Applications of adhesives.

National Starch Products Inc., New York.—Booth 28. Adhesives, Granite Board, and gluing systems.

State University of N.Y. College of Forestry, Syracuse, N. Y.—Booth 80.

N.C. State College, Raleigh, N. C.—Booth 83.

Oliver Machinery Co., Grand Rapids, Mich.—Booth 44. Woodworking machinery.

Onsrud Machine Works, Inc., Chicago, Ill.—Booth 2. Heavy production woodworking machinery, small portable air tools, air turbine routers, router bits, and cutters.

Pacific Mutual Door Co., Montainside, N. Y.—Booth 85. Fir plywood and West Coast lumber items for furniture, containers, luggage or surveyors stakes.

Pennsylvania State University, University Park, Pa.—Booth 78.

Perkins Glue Co., Lansdale, Pa.—Booth 34. Resin, casein and vegetable glues.

Power Line Sales, Inc., Detroit, Mich. —Booth 25. Air stapler, including a series featuring air return principle that utilizes supply of compressed air to drive staple and return piston.

Price & Rutzebeck, Hayward, Calif.—Booth 49. Carbide-tipped tools.

Projecting AB, Stockholm, Sweden.—Booth 50. Particle board equipment.

Reichhold Chemicals, Inc., White Plains, N. Y.—Booth 13. Adhesives and resins.

Senco Products, Inc., Cincinnati, Ohio —Booth 1. Demonstration of staplers and tackers, featuring models using low-carbon staples. A 16 mm. film was shown showing staplers in use under actual production conditions.

Simonds Saw & Steel Co., Fitchburg, Mass.—Booth 47. Complete line of saws, knives and files. Featured was a line of carbide-tipped saws, including rip, cut-off, combination, smooth trimmer, and groover saws, and dado heads.

S. H. Smith Co., Indianapolis, Ind.—Booth 16. Woodworker & Veneers and Plywood magazines.

Soderhamn Machine Manufacturing Co., Talladega, Ala.—Booth 53. Chipping and debarking equipment.

Standard Dry Kiln Co., Inc., Indianapolis, Ind.—Booth 30. Dry kilns.

Timber Engineering Co., Washington, D. C.—Booth 11. Display panels showing roof test, pilot-plant particle board production, bending jig, chemical drying, ladder test, end and edge jointing.

Tri-State Machinery Co., Dallas, Texas —Booth 51. Scale layout of finger jointing operation.

U. S. Forest Products Laboratory, Madison, Wis.—Booth 84. Use of low-grade hardwoods.

Victory Carbide Saw & Tool Co., Inc., Chicago, Ill.—Booth 33. Circular saws, groovers, dados, form cutters, router bits, solid carbide planer, moulder, and jointer knives.

Wel-Dri Co., Memphis, Tenn.—Booth 24. Bulletins and photos of custom-made dry kilns.

Wilco Machine Works, Memphis, Tenn.—Booth 54. Hot presses and woodworking equipment.

Yale University, New Haven, Conn. —Booth 88.

Yates-American Machine Co., Beloit, Wis.—Booth 37. Applications of double-deck sanders for surfacing particle board and production of hardwood flooring with use of flooring matchers were illustrated. Other woodworking machinery was also illustrated.

(Continued on page 71-A)

Catalin..... RESIN 8666

AN EXCEPTIONAL
Modified
Urea Formaldehyde

GAP FILLING CRAZE RESISTANT ADHESIVE

Catalin Resin 8666 is highly recommended for difficult assembly gluing jobs where uniformly thin glue lines cannot be obtained because of inadequate pressure or irregular surfaces.

Catalin Resin 8666 is a chemically modified, liquid urea formaldehyde adhesive. It yields exceptionally durable, craze resistant, gap filling, moisture resistant bonds. Perfect for assembly and structural wood gluing . . . Resin 8666 is also an excellent adhesive for bonding decorative laminates to plywood, wood cores or hardboards such as "Masonite." Write for samples and technical data.

In addition to Resin 8666, Catalin produces the industry's finest and most complete range of urea, modified urea, resorcinol and phenolic resin adhesives and accelerators. Catalin field representatives are qualified to assist you in adapting these formulations to your specific requirements. Inquiries invited!

Catalin

In addition to a wide range of Urea, Phenolic, Cresylic, Resorcinol and Melamine resin formulations, Catalin chemicals include Antioxidants, Bacteriostats, Oil Additives, Alkylation products and specialties as well as Styrene, Polyethylene and Nylon molding and extrusion compounds.

CATALIN CORPORATION OF AMERICA
ONE PARK AVENUE • NEW YORK 16, N. Y.

PLANTS:
Fords, New Jersey
Calumet City, Illinois
Thomasville, North Carolina

Minutes of FPRS Eleventh Annual Business Meeting

THE 11th ANNUAL BUSINESS MEETING of the Forest Products Research Society was called to order by President Ralph H. Bescher, at 4:15 PM, Monday, June 24, in the Ballroom of the Statler Hotel, Buffalo, N. Y. Seventy-five members were in attendance.

1. Minutes of the 1956 Business Meeting

The preceding annual business meeting was held in Asheville, N. C., June 5, 1956. The Minutes of this meeting were published in the October 1956 issue of the FOREST PRODUCTS JOURNAL. It was moved and seconded that the minutes be approved as published. The motion carried.

2. Annual Report of Executive Secretary for 1956 Fiscal Year

Frank J. Rovsek, Executive Secretary, reported that membership and subscription stood at 3,012 January 1, 1956, and increased to 3,456 on December 31, 1956, or a total increase of 14.7 per cent over the same period. Since January 1, 1957 total membership increased to 3,339 and subscribers to 279. The Northeast Section is the largest with 559 members, followed by the Pacific Northwest with 508 members and the Midwest Section with 367 members. The newly formed Rocky Mountain Section with headquarters at Denver, Colorado, is the smallest with 38 members. In addition to the United States, possessions and Canada, FPRS now has members in 42 countries throughout the free world.

During 1956 the 13 Sections held 25 separate meetings in principal wood industry areas of the U. S. and Canada. Every Section was active.

During 1956 the major program of the Executive Board, made up of nine elected officers and the Executive Secretary, was the promotion of the Executive Office Building Program and the corollary fund-raising drive, in an effort to erect a permanent national headquarters in Madison, Wisconsin. During 1956, plans were also made for the temporary move of the Society's executive offices from within the U. S. Forest Products Laboratory, where space had been leased for a period of 10 years, to offices about a mile from the laboratory. The transition was effected smoothly.

During 1956, the Society added a 14th Division by creating two Divisions from the former Logging and Sawmilling Division. The Divisions have made good progress during 1956 and are contributing equally with their counterparts, the 14 Sections, toward the overall development of the Society.

The Executive Secretary extended his appreciation to the more than 200 officers, committee chairmen, committee members and others who are responsible for the smooth functioning of the Society.

3. Report of Audit Committee

The committee consisting of Chairman Harold L. Mitchell, John T. Drow, and Kenneth E. Kimball, all of the U. S. Forest Products Laboratory, Madison, met with accountants Victor C. Hobart and I. H. Guthneck, and the Executive Secretary in Madison June 13, 1957. The committee examined the records of the Society for the twelve-month period January 1, 1956, through December 31, 1956, and reported that the following summary of the financial records of the Forest Products Research Society is a true and adequate statement of financial transactions during the year ending December 31, 1956, and of the current financial condition of the Society.

The Audit Committee recommended that up-to-date financial statements be obtained from all Sections at the close of the fiscal year. Adoption was also urged of auditor Guthneck's suggestion that a card system be set up for maintaining current records (purchase price, annual depreciation, date of disposal, and so forth) on equipment included in the equipment inventory.

The committee expressed appreciation to auditors Hobert and Guthneck for a job well done, and to Executive Secretary Rovsek for his cooperation with the committee.

FOREST PRODUCTS RESEARCH SOCIETY
BALANCE SHEET 12/31/56

Assets:	
Cash	$ 4,885.09
Anchor Savings and Loan Shares	10,000.00
Accounts Receivable	3,263.46
Executive Building Lot	9,952.70
Equipment Inventory	3,724.04
1957 National Meeting Advance	1,000.00
	$32,825.29
Liabilities:	
Accounts Payable	$ 13.70
Accrued Social Security Tax	69.74
Prepaid Membership Dues	2,124.50
Executive Office Building Contributions	3,193.48
Surplus	27,423.87
	$32,825.29

4. Report of the Editor

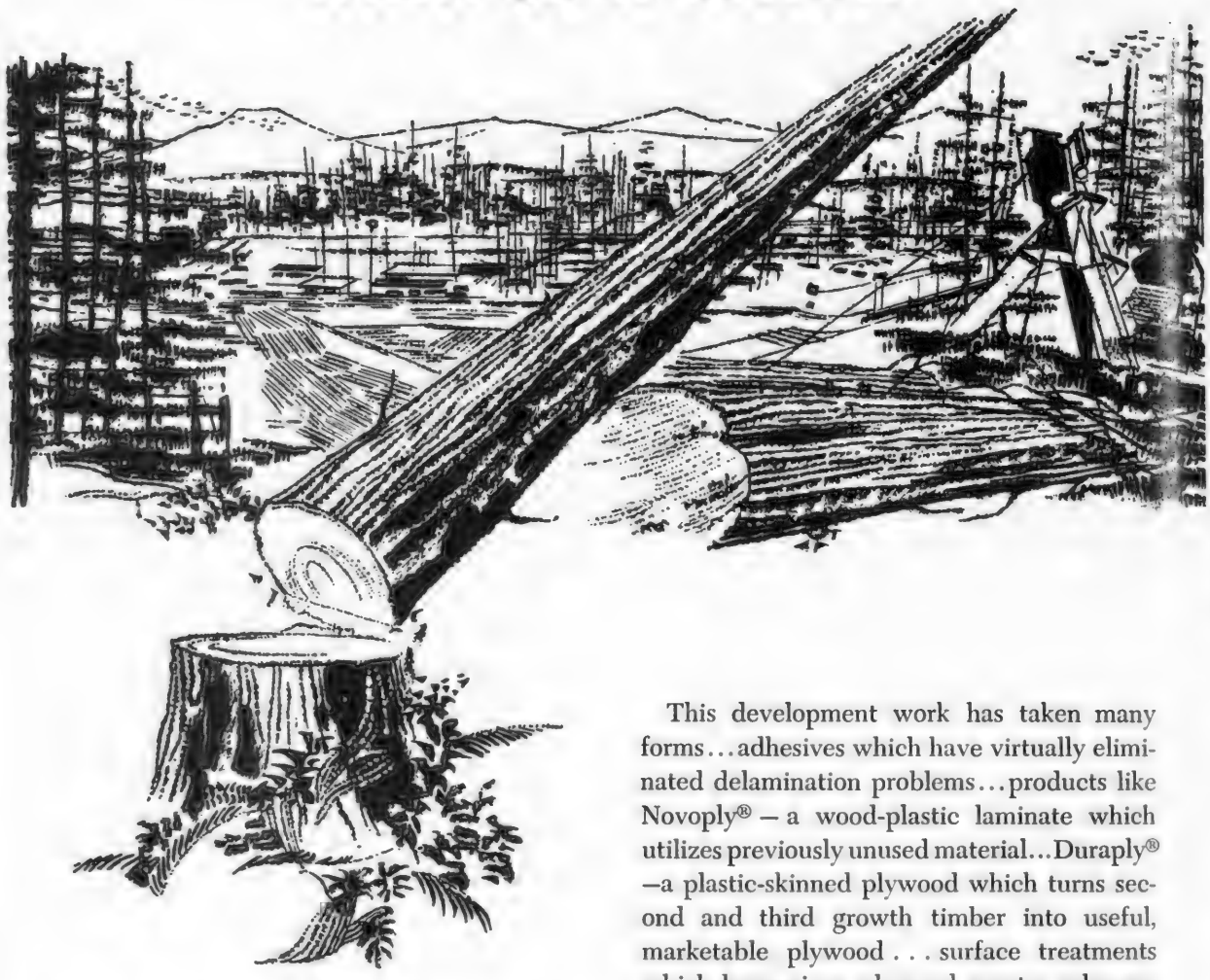
Editor Roche reported that there is approximately a 10-month backlog of articles compared to a 1-year backlog at the time of the 1956 National Meeting. It is expected that the backlog of papers on hand will be reduced even further. The present goal is to reduce the backlog to a six months' supply within the next year. Papers on hand include 64 Section or Region Meeting papers, 43 National Meeting papers, 30 contributed papers, and 24 Wood Award entries. Of the 160 papers, 12 are to be abstracted, leaving 148 full-length articles under consideration.

In the past year, 178 papers were received for consideration for publica-

FOREST PRODUCTS RESEARCH SOCIETY OPERATING STATEMENT—
C. Y. 1956 1/1/56–12/31/56

Cash January 1, 1956		$ 677.25		
Savings and Loan Shares		5,000.00	$ 5,677.25	
Receipts:				
1957 Membership Dues	$ 2,124.50			
1956 Membership Dues	45,222.68			
Dues Collected for Sections	5,310.00	52,657.18		
Publication Income		34,929.01		
Other Income:		727.11		
Executive Office Bldg. Contributions		1,518.48		
1956 National Meeting		21,531.44		
1956 National Meeting Advance from prior years		1,000.00	112,363.22	$118,040.47
Expenditures:				
Central Office Expense:				
Salaries	**30,138.96**			
Supplies, Equipment, FPL Agreement, Utilities, Internal Revenue, etc.	12,644.33			
Staff travel	1,375.38	44,158.67		
Executive Board Expense		438.63		
Real estate taxes and pledge cards		150.45		
Publication Expense		34,626.40		
1956 National Meeting		15,221.85		
1957 National Meeting Advance		1,000.00		
Section Dues Remittances		5,402.00		
Membership Campaign		1,343.62		
Membership Directory		813.76		103,155.38
Cash in Banks			4,885.09	
Savings and Loan Shares			10,000.00	
Total 12/31/56				$ 14,885.09

There's more in a log than just wood



To the United States Plywood Corporation a log is not just a quantity of wood to be processed and sold. Rather it is our means for creating new products for the American people and new markets for the entire wood industry.

For almost 40 years we have engaged in research that has developed just such products. It has also resulted in a more efficient utilization of our timber resources.

This development work has taken many forms... adhesives which have virtually eliminated delamination problems... products like Novoply® – a wood-plastic laminate which utilizes previously unused material... Duraply® –a plastic-skinned plywood which turns second and third growth timber into useful, marketable plywood . . . surface treatments which have given plywood greater sales appeal, in products such as Weldtex® and Surfwood®... and finishing methods which have widened fir plywood markets and have started the trend to prefinished hardwoods. These are but a few examples of research which has contributed to the health and growth of our industry and company.

To us a log will always be an opportunity to enhance our nation's economy... our industry's growth... and our people's way of life.

United States Plywood Corporation Weldwood

Weldwood—The Best Known Name in Plywood

CITIES where Section Meetings were held October 1956–May 1957.

PUBLICATIONS COMMITTEE

tion, and 152 have been published. Fifty-one were abstracted or returned to the authors for possible publication elsewhere. Sixty-nine articles have been published in the first six months of 1957, compared to 83 articles in the same period in 1956. The average length of articles has increased from 3.45 pages to 3.85 pages each. A total of 843 articles has been published since the first issue of the JOURNAL in 1951.

A revised style manual for aiding authors in preparation of FPRS papers was published in the last year. Copies have been made available to National Meeting authors, as well as to Section officers for distribution to authors of Section Meeting papers.

The cumulative index for 1957 will be published in the December issue, and the February 1958 "Annual Review" issue will again contain reports of developments in the past year in various segments of the industry.

5. Report of the Publications Committee

Chairman E. G. Locke reported that the committee recommended the following: 1) that a one-month deadline be set up for regional reviewers to notify the Editor of their opinions on a particular paper; 2) that the Executive Secretary and the Editor go over the list of reviewers to eliminate those who have been too slow in the past.

It was recommended that the Society not promise anyone publication of any material but merely request material be submitted for consideration. It was suggested that a statement of publications policy be published in a fall issue of the JOURNAL.

Recommendations on general publication policy were: 1) an author is not bound to accept suggestions of any reviewers, b) where an author has prepared a series of papers on any subject, the Society is under no obligation to publish any paper of the series not considered satisfactory by the reviewers.

Mr. Locke stated that the committee held a discussion on the problem of selecting abstracts for JOURNAL publication. The committee recommended that the Society should set up its own abstracting service.

6. Report of Twelfth National Meeting Committee

Robert L. Hiller, general chairman of the committee, reported on plans for the 1958 meeting to be held in Madison, Wisconsin, June 22–26, 1958. He announced that the steering committee consists of W. A. Kluender, finance and registration, J. J. Allegretti, local arrangements, John Killibrew, U. S. Forest Products Laboratory tours, Walter Noble, social arrangements, and Gardner Garlick, publicity.

Mr. Hiller emphasized that the principal attraction of the meeting would be group visits and appointments for private consultations with laboratory personnel on the Friday following the meeting.

The hope was expressed that progress on the executive office building would be such as to allow exhibition for the members. Recreational advantages in Madison will be at their peak at the time of the meeting, Mr. Hiller said. He expected that the 1958 meeting would be one of the best attended in the Society's history.

7. Report of National Membership Committee

Robert L. Hiller, National Membership Chairman, noted that on June 1, 1956, membership exclusive of sub-

FPRS SECTION MEETINGS OCTOBER 1, 1956 TO JUNE 1, 1957

Date	Section	Place	Attendance	Subject
Oct. 16, 1956	Upper Miss. Valley	Wausau, Wis.	.....	Hardwood Plywood
Oct. 24–25, 1956	Midwest	Rockford, Ill.	292	What is New and Needed in Woodworking Machinery.
Oct. 25–26, 1956	Northeast	New York, N. Y.	.....	Use of Wood in Modern Home Construction.
Oct. 29–30, 1956	Mid-South	Laurel, Miss.	125	Efficient Wood Utilization.
Nov. 8–9, 1956	Great Lakes	Grand Rapids, Mich.	.....	New Manufacturing Methods and Automation.
Nov. 15–16, 1956	Ohio Valley	Louisville, Ky.	.....	Furniture Manufacturing, Adhesives, Carbides.
Dec. 7–8, 1956	Fla.–Ga.–Alabama	Athens, Ga.	56	Hardwood Utilization.
Dec. 13–14–, 1956	Carolinas–Chesapeake	Pinehurst, N. C.	.....	.....
Jan. 17–18, 1957	Inland Empire	Spokane, Wash.	.....	Construction, Finishes, Patents, Log Storage.
Feb. 4–5, 1957	Pacific Northwest	Tacoma, Wash.	125	Wood Composition Boards.
Feb. 13, 1957	Pacific Southwest	Los Angeles, Calif.	.....	Smog Problems and Incineration.
Mar. 7–8, 1956	Eastern Canadian	Montreal, Quebec	100	Utilization, Waste—Chemical.
Apr. 11–12, 1957	Ohio Valley	Louisville, Ky.	75	Practical Methods of Solving Wood Technology Problems.
May 2–3, 1957	Northern California	Berkeley, Calif.	144	Particle Board Production and Marketing.
May 6, 1957	Rocky Mountains	Denver, Colo.	12	Present and Future Utilization of Forest Products in Rocky Mt. Area.
May 9–10, 1957	Carolinas–Chesapeake	Clemson, S. C.	.....	Urea Resin Adhesives, Veneer Drying, Dimensional Stability in Dry Formed Particle Boards, Labor Problems.
May 9–10, 1957	Midwest	Peoria, Ill.	30	Fibre Products, Cooperage Wall Materials.
May 13–14, 1957	Pacific Northwest	Roseburg, Ore.	85	Sawmilling and Plywood Manufacturing.
May 31, 1957	Fla.–Ga.–Alabama	Talladega, Ala.	66	Practical Applications of Economics of Recovery of Waste Fibers.

Ancient Miracle Material

2,365,476,967 *years*[1] before scientists combined air, coal and imagination to create our wondrous modern synthetics, a somewhat better "plastic" was developed.[2]

Among the first to recognize the unique advantages of this senior plastic was the chap at left who used it to fashion the world's first cudgel—a device then regarded as the ultimate weapon.

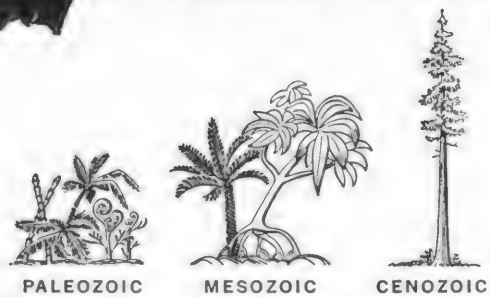
The familiarity which has diminished the novelty of this natural plastic makes it none-the-less remarkable today. For neither time nor new materials have replaced it as the planet's favorite and most versatile construction material.

The reason lies in this material's still unmatched combination of advantages. Its warm beauty defies imitation; every piece is custom made, no two are quite alike. It comes in a wide range of types, densities and sizes. Light, workable and marvelously strong, it has tremendous fatigue and impact resistance.

The basic method of producing natural polymer is quite simple. However, not inconsiderable skill and planning are required to make the process work most efficiently, as well as re-shape the basic raw material to best advantage.[3]

Of course, we do have important help. After all, the DuPonts and Monsantos make their synthetic plastics largely on their own, while our *natural* plastics industry has an excellent—and unique—supplier of semi-finished raw material.

Just like Joyce Kilmer says.[4]



[1] *Give or take a billion.*

[2] *This ancient miracle material is a natural organic ligno-cellulosic polymer, a true natural plastic commonly known as wood, composed of a complex of substances that has defied precise chemical definition.*

[3] *The basic process is called growth; the science of improving it forestry; the re-shaping is better known as forest products manufacturing.*

[4] *Surely you remember only who can make a tree.*

This is an advertisement? Indeed it is. Published on behalf of the forest "plastic" products industry by St. Paul & Tacoma Lumber Co., Tacoma, Washington, (a Subsidiary of St. Regis Paper Co.), to suggest that newness and utility are not always synonymous. Nor are promise and performance.

EMPLOYMENT COMMITTEE

BUSY TELLERS Committee worked far into the night counting election ballots.

scribers stood at 3,049. This increased to 3,339 by June 1, 1957. When 279 subscribers are included, the total figure is increased to 3,618, an increase of 10 per cent over a year ago. Since the figures were compiled on June 1, 1957, ten new members have been added to the Society's rolls.

Chairman Hiller reported that in the past year a state membership chairman reporting to the Section chairmen has been established for most of the 48 states and the provinces of Canada. Work of the National Membership Committee was described as working through the 14 Sections with the assistance of the National office.

For the third successive year, membership awards in the form of large banners suitable for display at Section meetings were presented to the following Sections:

Carolinas-Chesapeake Section—First award for the greatest gain 1956–57, presented to Section Chairman John Veach, Jr. The section gained 51 members.

Northern California Section—Second award, presented to past Section Chairman Homer Stephenson. The section gained 41 members.

Eastern Canadian Section—Third award, presented to 2nd Vice-chairman G. S. Billington. The section gained 32 members.

8. Interim Report of Chairman, Executive Building Fund Committee

Raymond H. Berry commended the efficient labors and cooperation of headquarters staff in supplying aid for the fund drive. Appreciation was expressed to those Regional Board members and Section Chairmen who gave time and effort for the drive, which called for much letter writing and many personal contacts.

Mr. Berry noted that the uncertain state of the current lumber market has tended to act as a brake on the fund raising campaign. As of the present moment, he said, the actual figures as to cash on hand and pledges received for the Executive Building Fund of the Forest Products Research Society are; pledges: $4,188, and cash $7,297.

9. Report of Employment Committee

Dr. Newell A. Norton, Chairman of the committee, reported that the major activity has been the operation of the Summer Placement Program for college students seeking vacation employment in industry. Thirty-two educational institutions in the U. S. and Canada and 53 industries cooperated in the program. Information on the number of students using the service was not completed at the time. More complete information should be available by the end of the summer, Dr. Norton said, at which time a supplementary report will be prepared.

The committee was unable to maintain its early pace throughout the Summer Placement Program campaign. Complications in both offices of the Executive Secretary and the Committee Chairman and difficulty in obtaining the necessary cooperating firms in two regions were contributing factors. Dr. Norton reported that the over-all procedure is reasonably effective, but the mechanics of operation require some overhauling.

The Society's Placement Service is operated from the Madison office. Sixty-two persons used this service since June, 1956. Of these, 53 were experienced personnel and nine were current college graduates. Forty-nine positions were offered during this period. Dr. Norton noted that these figures represent little change over the previous year. He recommended that the Employment Committee expend some of its efforts in improving this phase of activity. He recommended that the FPRS Placement Service should be developed to the point where it becomes the primary clearing house for the employment needs of the forest products industries and its personnel.

Because Dr. Norton felt he could best serve the employment interests of the Society at the Regional level, he announced that this year would terminate his service as chairman of the committee.

Thanks were expressed to the other members of the committee: E. A. Behr, E. R. Martel, R. W. Petterson, H. H. Smith and R. C. Carter. Appreciation was expressed to the staff of the Forest Products Journal for the excellent publicity given the committee.

10. Report of the Resolutions Committee

1. The Society records with deep regret the passing during the past year of the following members: R. E. Baker, E. Robert Hollinger, F. M. Velepac, N. W. Foster, J. A. McIver, D. K. Bemis, K. C. Birdsall, and G. J. Armstrong.

Be it resolved that this expression of sympathy to the families and friends of these men be included in the permanent records of this meeting and of the Society.

2. In appreciation of the meritorius services that have been rendered to the Society during their term of office,

Be it resolved that the gratitude of the Society be extended to all outgoing officers including Executive Officers, Regional Board Members and Section Officers.

3. Recognizing that the success of the 11th Annual Meeting of the Society is in large measure due to the foresight, planning, and diligence of the Annual Meeting Committee,

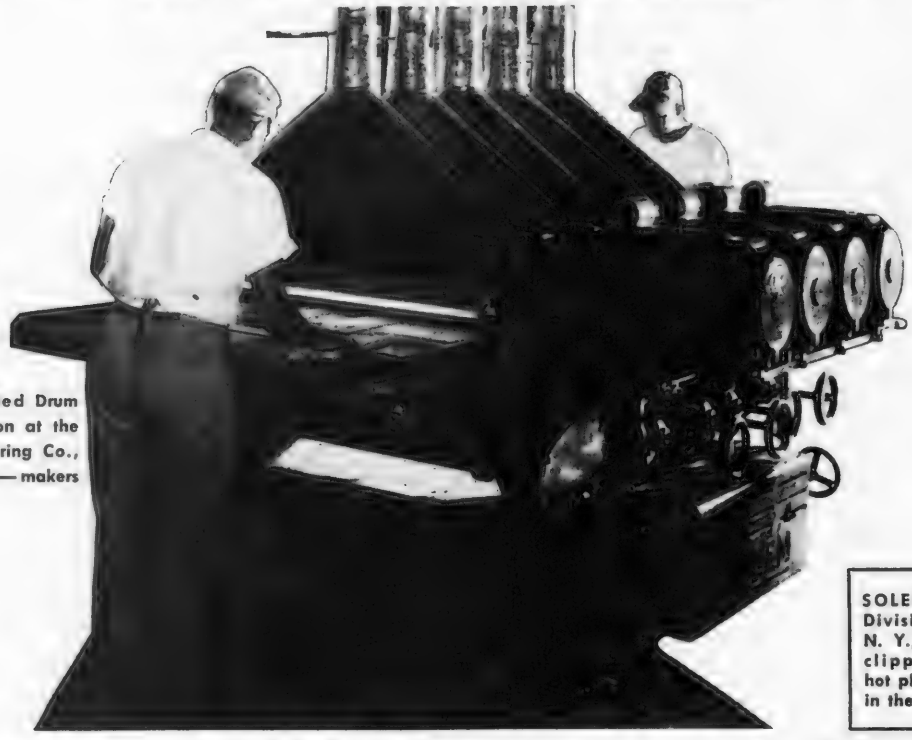
Be it resolved that the Society hereby acknowledges its appreciation to the members for their excellent and successful work.

4. In view of the splendid cooperation and services provided by the Statler Hotel in helping to make this Annual Meeting a success,

(Continued on page 93-A)

SOLEM SANDERS FOR A SMOOTH FINISH

AND THEY'RE SO DEPENDABLE!



Solem Endless-Bed Drum Sander in operation at the Keller Manufacturing Co., Corydon, Indiana — makers of furniture.

SOLEM'S Merritt–Solem Division of Lockport, N. Y., makes lathes, clippers, jointers, and hot plate presses for use in the plywood industry.

TO ALL OWNERS OF MERRITT–SOLEM EQUIPMENT

Pay no attention to misleading rumors or implications that Merritt–Solem equipment will no longer be built. This is not true. The full line is still being made, and will continue to be produced in the large plant we are building in Rockford.

Merritt–Solem Division will appreciate your continued orders for parts, subassemblies, and new machines. It is safer to purchase your parts from the machine builder.

SOLEM ENDLESS-BED DRUM SANDERS

If your product requires a smooth finish, you'll increase your production with Solem Endless-Bed Drum Sanders. We make this statement because it's been proven in other wood product plants. The replacing of old worn-out machines with a new Solem does make a difference that shows up on the profit side of the ledger.

A SIZE AND TYPE FOR YOUR PARTICULAR NEED

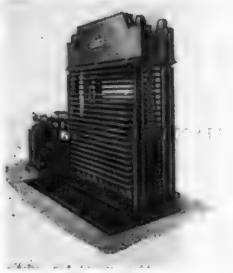
SOLEM Endless-Bed Drum Sanders are made in 2, 3, and 4-drum models in a variety of widths. Solem also has 4, 6, and 8-drum sanders of double-deck style. There's a size to fit your plant and cut your production cost.

DEPENDABLE SOLEM SANDERS

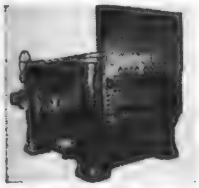
It makes little difference to a Solem, whether you work one, two, or three eight-hour shifts . . . they stand up under the constant pressure of day-in, day-out production. The dependability is built in.

Write Today for Information

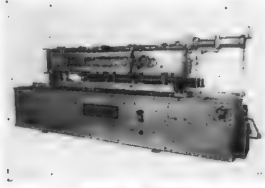
Veneer Clippers



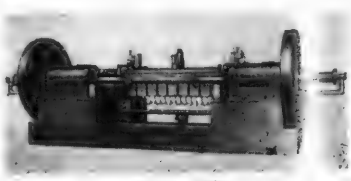
Hot Plate Presses



Double-Deck Sanders



Veneer Jointers



Veneer Lathes

SOLEM MACHINE COMPANY

ROCKFORD, ILLINOIS

Report of Section Officers—Executive Board Meetings

SECTION OFFICERS Advisory Committee met with the Executive Board; they unanimously endorsed the home office building program.

THE EIGHTH ANNUAL LUNCHEON MEETING of members of the National Executive Board and Section Officers and their delegates was held Thursday, June 27, in the Detroit Room, Statler Hotel, Buffalo.

A highlight of the meeting was the commendation of the National Board for the building program and a pledge of unanimous Section support for the program.

It was also recommended that abstracts of the Executive Board minutes be provided to those persons designated by each Section chairman. It was suggested that a definite publication policy be made and published in the JOURNAL for the benefit of members and subscribers.

Those attending the meeting were: Eric A. Anderson, Northeast; Robert Archambeault, Midwest; Ray H. Berry, Northern California; R. H. Bescher, Northeast; Fred Dickinson, Northern California; J. F. Burell, Ohio Valley; Wm. J. Delmhorst, Northeast; W. Jeter Eason, Mid-South; Norman C. Franz, Great Lakes; B. M. Granum, Upper Mississippi Valley; J. Allan Hauter, Northeast; Robert L. Hiller, Midwest; W. L. Irwin, Carolinas–Chesapeake, E. P. Ivory, Northern California; Wm. Kluender, Midwest; Paul Lane, Upper Mississippi Valley; W. L. Lear, Mid-South; Rufus H. Page, Florida–Georgia–Alabama; S. B. Preston, Great Lakes; F. J. Rovsek, Executive Secretary; D. K. Saunders, Northeast; Homer N. Stephenson, Northern California; J. R. Stillinger, Pacific Northwest; W. R. Warner, Mid-South; and Tony Veazey, Inland Empire.

1. President Kaufert called the meeting to order at 1 P.M. The minutes of the June 7, 1956 meeting were read. These called for pertinent Section correspondence to be sent to the chairman and secretary of each Section as well as to the regional board members; cooperation with NLMA in preparing a career brochure in conjunction with the Industry–Education Division; quarterly reports on the status of Section papers submitted for publication in the FOREST PRODUCTS JOURNAL; the addition to the style manual of the procedure for submitting and publishing Section papers, and for the continuation of the existing policy on preprints of National Meeting papers.

2. President Kaufert then turned the meeting over to Acting Chairman of the Section Officers' Advisory Committee, William Kluender, who substituted for Joseph Allegretti, permanent chairman. Mr. Kluender stated that prior to the Section officers' meeting Monday evening, June 24, three Sections requested that the entire matter of the Executive Office building program be discussed. Such discussion was held on Monday evening with representatives of the National Executive Board present (Messrs. Berry, Eason, Irwin and Rovsek). As a result of this discussion, the Section Officers' Advisory Committee moved as follows:

"Be it resolved: That the Section officers favor the proposed building program and commend the National Board and Building Committee for a job well done.

"Be it further resolved: That the Section officers pledge the full support of their respective sections to the successful completion of the program.

The resolutions received a unanimous vote.

3. It was recommended that abstracts of the Executive Board minutes be provided to those persons designated by each Section chairman. In later action, the Executive Board moved and seconded that the Eexcutive Secretary send to all Section chairmen the same copies of the Executive Board minutes that are sent to the Regional Board members and National Officers.

4. The committee recommended that publication of duties of FPRS Section officers be withheld until each Section chairman has had an opportunity to review the manuscript. If comments are not returned to the Executive Secretary by October 15, it will be assumed that the chairmen approve of publication in its present form. The Executive Board instructed the Executive Secretary to submit the manuscript for final review and to proceed with publication as of October 15.

5. The committee recommended that a definite publication policy be established, and that the policy be published in the JOURNAL. The task of recommending a publication policy is now in the hands of the Publications Committee for preparation and submission to the Executive Board.

6. It was recommended that adequate space be made available in the JOURNAL for publishing Section meetings. The Executive Board concurred that steps be taken to strengthen the Section news feature of the JOURNAL to the limit of the budget in terms of pages available. The Executive Secretary was instructed to issue postcard notice periodically to the Sections in order to obtain more thorough Section news coverage.

(Continued on page 93-A)

reforesting the land to produce more wood for tomorrow...

Some of America's most distinctive homes are built of western red cedar. This wood species is one of many marketed under the Weyerhaeuser 4-Square lumber trademark.

It is the forestry policy of this company to properly manage its tree-growing lands so that they will be productive...forever. On these timber lands, trees are being grown in repeated crops under scientific forestry practices that provide for prompt reforestation of all harvested areas.

By careful planning of mature-tree seed sources, about 85 per cent of all harvested lands are restocked by nature. In areas where the seed crop has failed, new trees are being established through the use of artificial methods...such as hand planting and aerial seeding.

To date, about 33 million seedlings have been planted on 50,000 acres. An additional 50,000 acres have been seeded by helicopter or treated for rodent and brush control to facilitate new tree growth. During 1956, we collected and removed seed from 43,000 bushels of cones and began growing about 10 million new seedlings in forest nurseries for future planting.

By such intensive restocking programs, based on good forestry, our tree farms can supply present and future generations with a continuous flow of wood...for use as lumber, plywood, pulp and other forest products. *Write us at Box A, Tacoma, Wash., for free booklet,* ***Promise of the Trees.***

Weyerhaeuser Timber Company

making wood serve America better through good forest management

FPRS Forest Products Journal

Vol. VII, No. 10
October, 1957

OFFICIAL LUNCHEON ADDRESS, FPRS 11th NATIONAL MEETING

The Challenge of Forest Products Research

FRED C. FOY

President, Koppers Company, Inc., Pittsburgh, Pa.

A leading advertising and sales authority—turned technical executive points out the need, in his Official Luncheon Address to the FPRS 11th National Meeting, for forest products research, then traces past developments, cites six major areas for future development, and places responsibility for research on both industry and government.

Introduction

WHEN FIRST APPROACHED to speak before your meeting, I had a serious mental reservation. What could I possibly say to a group of technical experts in a field where my own experience has been necessarily limited to non-technical matters?

Then it occurred to me that I have a very decided stake in the same pursuits as you, furthering the activity and competence in research related to the forest and forest products. As a matter of fact, all of us have a responsibility to further research in all fields of interest—industry, agriculture and human relations.

My own convictions were strengthened considerably by a story I heard recently. I think it has to do with research. I'll let you draw your own conclusions from it.

Just after World War II, it seems there was a company that was the leader in the manufacture of a certain type of very specialized machinery. I'll not mention the name of the company, for reasons you'll appreciate in a moment. Well, this company had a fine product, it knew it, and it made the most of it. It's hallmark on a machine was a sign of dependability, excellence and integrity. But something was wrong. As the years passed, this company started to slip—to second, then third. Today, this company ranks fifth in its industry and is having a hard struggle just to stay where it is.

One of their production engineers visited our development laboratory at Kobuta, Pa. recently to get some technical assistance from our development people. This engineer stated flatly that his company didn't feel it could afford to conduct research. He further said that the company had never even set aside one of its own machines for development purposes!

This is a true story, and one that seems to have a pretty pointed moral.

Now you might well ask, "What has all this to do with me or with my company?" The chances are that you can ask that question in all sincerity. For I'm happy to say the company in my story now represents an exception in American industry.

We as a company, an industry, a complex of industries, a duly constituted government, as a total people, have come to recognize research as a vital ingredient to progresss. And we needn't try to kid ourselves; in these days progress is synonymous with survival!

Consider the massive problems that are facing the world in general, and this country in particular. What I have in mind specifically are problems such as those surrounding the world's rapidly growing population, its ever-increasing need for practical sources of power and, more akin to your interests, the better utilization and conservation of our natural resources, some of which are sorely limited or sadly depleted.

Yet with all these bewildering difficulties ahead we look forward to the future with confidence, even optimism. Why?

There is a new confidence in our land. It is a confidence born of faith in ourselves, a faith that through research we will find the answers to all these problems. This is a pretty wonderful endorsement of research and what it can accomplish for us. And what is more to the point, it reflects the assurance we all feel that we are right!

Evolution of Research

Now this feeling of the "rightness" of research has come about only in recent years. Of course, many of the scientists among you, and in all fields, have been convinced of it for much longer that that. But the real recognition of research, and what it can do, took place during and since World War II. The real wonder is that our science and technology was able to accomplish as much as it did prior to that time. But let's demonstrate the point by considering the forest products industry.

I can't take you back far enough in time to pinpoint the moment when man first appreciated the utility of wood for fuel and as a structural material. There is considerable evidence that the forest products industry can make a very strong claim to being the second oldest profession!

Perhaps one of the most convincing arguments for the easy utility of wood is that no age of man was named for it. The Stone Age, the Bronze Age, the Iron Age—all represented periods in man's progress when through self-instruction and trial-and-error he was becoming familiar with and mastering these materials. During the entire time, however, he was using wood, in ever more abundant and ingenious ways.

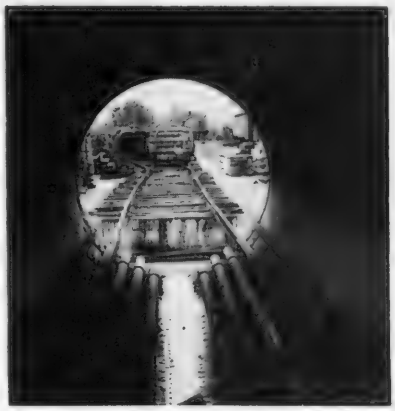


Fig. 1.—Inside view from a preservative-treating cylinder.

The Author: Fred C. Foy is a graduate of the University of California, Berkeley. After working in advertising and public relations for more than 20 years, with time out for World War II service with rank of Colonel, Foy joined the Koppers Co., in 1948 as vice president of sales. Named v. p. and general manager of the Tar Products div. in 1950, he was elected to the board of directors in 1954, and named president in 1956. A frequent contributor to major business publications, he is considered an authority on communications.

All this was roughly a million years ago.

As with most other sciences, it is impossible to pinpoint the exact moment that research began in forestry. I suspect it was born of a realization that some barony's wood supply was being used up and not replenished, the need of some feudal lord for wood to rebuild his manor after it had been sacked and burned and an understanding that the thinning cover had decimated the wildlife to be found in the kingdom's hunting preserve.

We can be sure at least that forestry research began first in Europe, probably in elementary attempts at reforestation. By the time similar efforts were felt necessary in the Western Hemisphere, Europe was already well-progressed in forest technology.

At this point, I'd like to interject a thought or two I've had about research. I have heard the opinion expressed that the great achievements in fundamental research were nurtured best in the academic freedom and detachment of great European universities. At the same time, American

Fig. 2.—Laminated minesweeper ribs designed to have strength where it is most needed.

science has been described as the master engineer, the adapter and combiner of the research efforts of others. I have serious doubts that this is true. As said before, I believe that research is conducted to meet a need, and that man's scientific accomplishments will reflect these needs wherever he may be.

I believe I can demonstrate this fact in one area of our own field. One of the earliest recorded uses of preservative treatments for wood took place in the early 1700's almost simultaneously in Europe and the United States—to be exact, a difference of only 10 years. Most of the subsequent developments, however, proceeded in Europe while the treatment of timber was of no practical significance in the United States until after the middle of the Nineteenth Century. I'll have a little more to say later about wood preserving, but I'd like to nail down this point. It is

Fig. 3.—A truly modern wood ship, the U.S.S. Bittern, made with preservative-treated lumber and laminated frames.

my contention that Europe feel the need for preserving the life of its wood products far earlier than the settlers of the New World. Why, in 1700, our forefathers had barely even begun to cut the tremendous supply of virgin timber on the Eastern Seaboard alone!

From about the middle of the Nineteenth Century, research in forestry and forest products began to stir as a part of the Industrial Revolution. Although it lagged somewhat behind the volume of inquiry stimulated in the physical sciences, its pursuit was a natural and logical result of the scientific curiosity of the times.

It was around the turn of the Twentieth Century that American industry began to assume its corporate character. At this time the beginnings of many of the present-day industrial giants were established. Research and technology also began to produce tangible results.

I'd like to revert again to wood preservation in discussing the progress of forestry research. While it represents only one aspect of our over-all interests, it is fairly typical of most forestry research except the most fundamental and I feel on more familiar ground in discussing it, since it is a primary activity of my company.

Perhaps the most significant advance in wood preservation technology was the practical application of pressure treatment to wood preservation. The first plant to be built offering such treatment by one of the three predecessors of the Koppers Wood Preserving Division was at Carbondale, Ill., in 1902. But "progress of the art"—and a lot of our technical skills at this time were more of art than science—was slow. It was 1925, in fact, before our company felt impelled to hire a chemist to further our knowledge of preservatives and treatments. And even at that, we were among the first in the industry to take wood preserving research into the chemical laboratory. Industry in general had not yet come to the realization of the value of research.

For example, in 1926, the total expenditures for forestry research in this country were a little more than 2½ million dollars. This compares with expenditures during 1953, the most recent year figures are available, in the neighborhood of 50 million dollars. This is a very significant increase, and the prospects for the future are even greater intensification of research efforts.

Incidentally, I was interested in an editorial comment that accompanied the chart from which I got the above figures. It said in effect that although the two figures pointed up the significant increase in forestry research over 25 years, it was more a reflection of the inadequacy of 1926 research funds than an indication of the adequacy of present allocations for research!

We have now reached what may come to be known in time to come as the period of scientific enlightenment. The scientific progress of the past decade has been phenomenal. It is carrying everybody with it, instilling a new and curious enthusiasm as well as a nagging impatience that we could and should be getting on with the job even faster than we are.

Just exactly where do we stand today in relation to forest products research? It is a remarkable contrast to conditions we were familiar with in the past. Industry has picked up the biggest part of the tab that has so far paid for forestry research. And, as a result, the lion's share of these efforts has gone into the development and utilization of forest products.

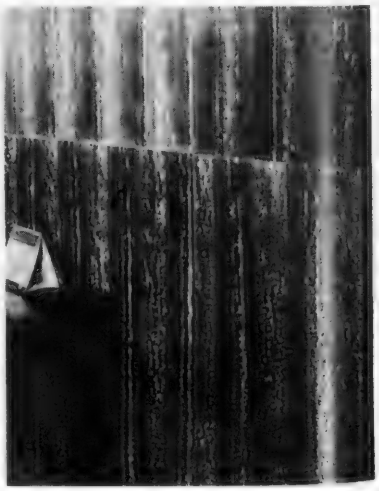


Fig. 4.—White-pocket Douglas-fir, usually discarded as decayed wood, can be made into attractive paneling.—U.S. F.P.L. photo

Underlying such progress is a certain subtle change that has come about in ideas and approaches to wood. Lest this seem vague, let me give you some examples.

Upgrading Quality

The best way to describe this change is that we have come to appreciate wood as a quality structural material. This is in direct contrast to the past, in which wood was regarded widely as the abundant, therefore cheap, material for construction.

But let's look at some of the tangible results of research that have wrought this change in attitude.

In attempts to utilize more of the timber that previously went to waste, means have been developed to fabricate large structural members of superior strength through lamination of small pieces into a larger unit. This has come about with the development of better adhesives and improved techniques of lamination.

Ways have been found to treat wood to adapt it to a variety of both interior and exterior structural and decorative uses. It can be made termite and fungus proof, fire resistant, structurally stronger, moisture and decay resistant. With treatment wood, in many applications, can be considered a permanent building material.

Every day, research is carrying us to the time when we will use, not only every ounce of material in the harvested tree, but also the total of thousands of weed and cull trees we could not previously utilize.

Fig. 6.—Genetic studies are being made to determine how the two trees in the foreground, which are of the same age and diameter, can be so far apart in specific gravity (0.46 and 0.56).

In the field of forestry genetics, work is now getting underway in the cross-breeding of certain species of timber to develop properties in wood to meet the requirements of specific types of applications.

Upgrading in the quality of wood products has brought about a substantial increase in the per capita consumption of these products, particularly for uses that have been developed recently or for uses where better quality has brought about an augmented market. I am thinking of such products as plywood, paper, laminated timbers and particle board.

And this is not even to consider all the work done to adapt wood with its many superlative natural properties to uses in which it is replacing other types of structural material.

Finally, I consider the fact that we are now replacing our forest resources at a faster rate than they are being consumed as a research achievement of paramount importance. It is even more noteworthy when you appreciate the staggering rate at which our utilization and consumption of forest products have been increasing in recent years.

In my own phase of the business, I am enthusiastic about the potentialities of some of the new applications for preservatives and different types of pressure treatments, as well as some of the new applications for time-tested preservatives that are opening up in industry, on the farm and in the home. I am sure all of you have equally exciting projects that you regard with particular feeling of kinship and enthusiasm.

Now what is no "subtle" about the very real improvements I have just outlined?

When you think about it, the changes mentioned above have generally increased the price of wood, but, at the same time, have made it measurably more competitive with other structural materials. In effect, research has given to wood properties that make it superb, often unexcelled, in many applications. This is not a matter either of an occasional exception. It is a trend of great importance. A quality product—we know it's good! And we know it's getting better every day.

What all this means, is that the industry has been, and is still going through a remarkable period of change as regards research. And it is not only our industry, or all industry, but every facet of society. I can thing of no better way to describe it than through the term I used a little earlier—enlightenment!

The Future

But what of the future? We are convinced that research is important.

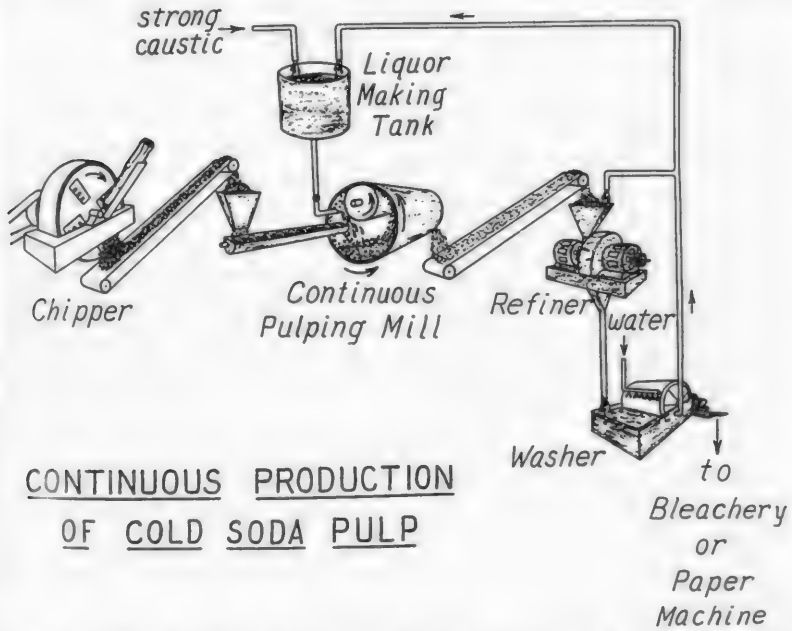


Fig. 5.—Many hardwoods previously considered unusable can be converted to fiber products through the development of new processes such as the cold soda process.—U.S. F.P.L. photo

It is still increasing significantly. Is this enough? I suspect that this is as good a time as any to say a word or two of disenchantment. I say disenchantment not discouragement! I hope that all of us will be able to draw from it just the kind of challenge we can thrive on.

And that brings us to our present problems.

I recently talked to some of my colleagues about the major problems of forestry research. For proper background, I asked them to choose the five or six most important questions facing research in forestry.

I'll say this, they got the most out of my condition that they could. When all the discussion was over, they had outlined the six problems whose solutions they felt would contribute most to the progress of forestry. Perhaps you won't agree with their analysis in all respects, but I'd like to repeat them for your benefit. I might also add they did not attach any particular importance to one problem over another.

One, they said a means should be found to expand and intensify the utilization of hardwoods by the pulp and paper industry. In its current budget recommendations the Department of Agriculture also recognizes this as a major problem, particularly as it could affect the economy of our Southern states.

Two—and I'm going to recite their recommendations as though they were my own—we should obtain the technical and engineering information on which to base a diversified chemical industry utilizing low grade wood as a raw material.

Three, we should develop a means of using lower grade solid wood by finding applications in which these woods could be economically utilized by combining them with other materials. The example of such applications that come to mind first is that of impregnated paper overlays by which low grade lumber can be used for siding and building panels.

Four, we should develop economical and satisfactory methods to make wood more dimensionally stable. I might add as an aside that my own company has been investigating this for some time, and that the one difficulty that we have not yet been able to overcome is expressed by that word, "economical."

Five, we must continue to develop less expensive and better methods of wood preservation and for the fireproofing of wood.

Fig. 7.—Paper overlays increase paintability, reduce shrinkage and swelling.

And finally, six, we must develop management methods dependent on genetics and selection to improve the quality and yields of our timberlands.

Quality Factor

Now, thinking over all these separate research tasks, I am impressed with a certain unity running through them. Every one of the problems posed by my colleagues represents a challenge to upgrade the quality of wood. Even the problems we face having to do with the utilization of low-grade forest products has the basic underlying assumption that lands presently stagnated by such growth will be returned to full high-quality production.

We have a responsibility to devote our best efforts and influence to see that this quality factor continues to advance on all fronts, that it continues to be the focus of our activities and that it continues to be our spark and inspiration.

I sincerely believe that we must step up this program of research to improve the quality of wood and wood products.

Responsibility for Research

Now, where does the responsibility for carrying on such a program lie? I have some ideas about that!

I would be the last one to say that industry does not or will not engage in programs of what we call "pure" research. It is natural, however, that the major portion of its research money be expended toward development of products for which it can currently envision a market.

Yet in this field of wood, there is a great need for the "pure" type of research that will add to our fund of general knowledge and lay the basis for future broad advancement.

I firmly believe that there are areas of research and development that should be the sole responsibility of industry.

There are other areas, however, in which the fruit of more-or-less "pure" forestry research may be the food to encourage economic growth and welfare of a sizeable segment of our nation. And there is no reason why government and state agencies should not carry on more work in this direction in much the same fashion that they now carry on other agricultural research to aid the farmers of the nation.

For instance: In the problems outlined previously, I believe it to be the sole responsibility of industry to develop better methods of wood preservation, stabilization and fireproofing.

On the other hand, I believe that basic research in the cross-breeding of trees—another of the problems listed—also properly may be conducted by government agencies because such work is aimed at improving and upgrading a major national resource for the ultimate benefit of all the people.

This does not preclude the value and need of teamwork.

We will undoubtedly find many areas of investigation where results will benefit us all. Efforts in the past indicate that we appreciate the advantage of working together and I am sure that our future activities will continue to bear this out.

I hope I have been able to convey to you something of the wonderful confidence I feel personally in the value of research, the "rightness" of research, the contributions research is and will be making to our way of life.

For this is actually the challenge that we face—to translate the labor of the laboratory and the patient diligence of the field staffs into a richer and more abundant life for all our citizens. I don't have any doubts that each and every one of you can be counted on to do his part.

I will close then with the promise that I, too, shall be doing mine

Everything, Including the Smell[1]

DR. LINCOLN R. THIESMEYER

President, Pulp and Paper Research Institute of Canada, Montreal, Que.

Disposal of liquid, gaseous and solid waste materials is poor public relations as well as a waste of money. Recovery of waste materials can pay rich dividends in cutting down pollution and developing profitable by-products. Several approaches to the problem are discussed, including the recently developed "AST" process.

Introduction

TODAY THE ATTENTION of public officials, sportsmen's groups, employees and the general public is centered upon the "garbage" of a whole industry or group of related industries —lumber, pulp and paper and many others.

This concern is centered on three types of wastes: The *solid* residues from logging which accumulate in too many forests as a fire hazard, and those from barking and sawing which pile up to rot at too many pulpmills and sawmills. The *liquid* slurries and solutions which carry millions of tons of useful materials into sewers and drainage valleys every month. And as expressed in the title, thought should be given to *gaseous* effluents which no longer should be rationalized on the ground that the smell signifies pay checks also are pouring into the community.

Pre-occupation with industrial wastes is not an unusual phenomenon. Thousands of research workers have studied these matters for years. And one of the main objectives of the Forest Products Research Society is the reduction of wastes through fuller utilization of raw materials.

Opportunity Ahead

There is no need to review the long list of products which have been made in the laboratory from the non-lumber and non-pulp components of wood. A mere listing of the plants which are now in profitable operation converting wood wastes into some of those products commercially would cover many pages. Yet, despite all the effort and expenditure which that impressive record represents, the surface barely has been scarcely scratched.

A few years ago a vice president of a large chemical company told a convention of the American Chemical Society that, in his opinion, no greater opportunity (outside atomic energy) faced young chemists and chemical engineers than lies in the drive for utilization of the solid, liquid and gaseous wastes of the lumbering and the pulp and paper industry. This also should include the foresters, mechanical engineers, hydraulic engineers, and even some biologists. The job to be done is complex and cannot be handled by the chemists alone. Indeed, their talents hardly come into play until the wood has been harvested and subdivided and gathered at central landings.

Slash is of little value until it can be collected and deposited in large accumulations economically. Bark and sawdust cannot feed retorts and digesters, when they are spread across the landscape. When the harvesting isn't done properly, the economic gain from by-products will be cancelled by the losses from logging damage to the forests. Thus, complete utilization demands teamwork and the interplay of many disciplines of science and engineering.

Those in the research business are convinced of the ultimate value of this work. They point elatedly to the pay-offs which have come to companies whose research programs have been vigorous, and dream up such evangelistic statements as "research is the guarantee of an industry's future". But actually it is informed and intelligent management which makes effective research possible. Although some very backward types still occupy senior posts in industry, managements generally are stronger, better informed, more alert, broader gauged and more far-sighted than ever. In company after company the top spot is today or will be tomorrow, filled by a man whose basic training was technical rather than financial. The scientist and engineer are beginning to take over the reins, just as they have in the petroleum industry during the past 25 years. So the future for forest products utilization looks very bright, indeed, because better management will make possible more and better-supported research.

Not too many years ago, managements on this continent began to recognize that trees are a renewable crop and that to treat them as such is not only in the public interest but also in the purely selfish interest of the companies themselves. It is not necessary to talk about change that came over industries when sustained yield became the general policy and practice, nor what broadened and intensified demands were thereby placed upon research.

Today there is another change spreading across the thinking of management which will have equally sweeping results. This is a growing recognition that the forest is truly a part of the whole manufacturing plant and should be treated as such—that pulp and paper and furniture and lumber and the whole array of forest products are manufactured from seeds.

Therefore, the best managements today no longer regard as long-term investments the money they spend on forest genetics, silviculture and fire protection. They treat these expenditures as maintenance and improvement of a major part of the total manufacturing plant. And they have come to realize that they need not wait for years to identify a return on such outlays. The benefits can be immediate and can be seen in dollars and cents within the operating year.

For example, when a forest improvement method is applied to one part of the company's operating limits, that company can immediately cut more

[1] Keynote address at the General Session, FPRS 11th National Meeting, June 23–28, 1957, in Buffalo, N. Y.

The Author: Dr. Lincoln R. Thiesmeyer is a graduate of Wesleyan and Harvard Universities, receiving A.M. and Ph.D. degrees from the latter. He was on the faculty of five universities and did technical work for nine years before assuming his present position in 1950. He is a director of Isotope Products Limited and a sponsor of courses on atomic energy for management in the U. S. He is an author of some 30 research publications, manuals and books.

wood than it could otherwise from some other part of its limits. This means more logs in the woodyard that year.

Approach to Research

The A-plus managements who have adopted this concept are now asking the research boys to "get cracking" on the hand-tailoring of trees to meet end uses. And, here, the thinking of managements is way ahead of research. They want the best possible raw material for each forest product. The archaic ideal of "more cellulose per acre"—any old kind of cellulose, on any old acre—is giving way to the more rational ideal of "to each his own", or "let's have each acre grow, as fast as possible, the best damned trees for the use we have in mind as that acre can produce—and, if Nature needs to be humored by some aerial fertilization, or selective cutting and thinning, or herbicidal applications to keep down the hardwood overstory and favor the softwoods, or spraying to eliminate budworms, or even meticulous selection of seed trees or seeds, let's get on with it!"

The problem for the research people now will be to contain the impatience of such managements. Forestry and forest products research have had such "slim pickings" over years past that there are many, many questions still unanswered about how God proceeds to make each tree and about how man can take fullest advantage of its particular characteristics. In other words, this new conversion in management thinking is opening up enormous areas for research. Tons of money will be needed in the quest for the best fibre from each acre, the best product from each fibre and the complete use of everything, including the smell. But the rewards may well be twenty tons of new money for every ton devoted to that quest—a nice, earthy incentive to motivate management decisions.

If the forest and the pulpmill are parts of the same overall factory, then the technical men of each are all on the same team. The chemist who studies the distribution of lignin in the individual cell in order to improve a bleaching procedure should work closely with the geneticist or the tree physiologist who may be able to control that distribution in the first place. This is such an elementary concept. Yet, in how few places do the woodlands researchers, the technical control departments and the mill research departments even know each other's first names! But that will now be changing rapidly. And eventually, the precision of technical control will be extended back into logging operations and even to the selection and planting of seeds and the nurturing of the oncoming generation of trees.

Meanwhile, the economic pressures from skyrocketing labor costs are making it mandatory that harvesting methods be completely revolutionized. Gradual, evolutionary improvement of conventional woodlands procedures is inadequate.

Problems in Mechanization

Piecemeal mechanization of the various operations in logging is stepping up the cords per man-day and reducing the total manpower required. But this increased production is achieved at an alarming increase in capital equipment costs per worker. It establishes the same sort of trend which brought the mills to their present condition of gigantic size and staggering capital plant cost. And it does very little to increase overall utilization.

The slash, the leaves and needles are still left scattered about; the stumps are lower but the roots remain. Hence, about 30 per cent of the tree is still wasted. Recovery of this would alone pay for a good deal of mechanization. But the operation continues to require a great deal of handling and re-handling of the wood from stump to mill—more of the handling now by machines, than by men, but constituting very costly repetition and entailing losses of wood substance at place after place on the intermittent journey of the log to the chipper or the gangsaw. Altogether, the most complete mechanization of this kind still results in a complex sequence of batch operations.

Modern technology has proved in one manufacturing industry after another that conversion from batch to continuous operations repays many times over the cost of the development work and then of the conversion. It seems, therefore, that our wood-using industries should be seeking with far greater vigor the continuous operations which start with full-tree logging, or what Sproull calls whole-tree harvesting, whatever the terrain, the tree sizes and other conditions will permit.

And pulp producers should be investigating very intensively the technology and the economics of chipping in the woods and then sending the chips through pipelines, or by monorail trains, or by cableways, overland to the mills, to eliminate a vast array of machines and men now needed by intermittent batch transportation systems. They should do these things now, before they get such a sizeable sum of money tied up in mechanical equipment for the many separate steps in an evolutionary sequence that they become loathe to think about these possibly even more rewarding revolutionary conversions. At the mills, the trend to continuous chemical pulping is well established, but it proceeds all too slowly because at so many places such huge investments in conventional batch plants must be amortized before they can be declared obsolescent. There is yet time to avoid getting into a similar situation with respect to our woodlands operations.

One of the most attractive features of full-tree logging, or whole-tree harvesting, is that it automatically solves the economic problem of gathering what would have become scattered slash and thereby creates conditions favoring full utilization. Indeed, if large tonnages of logs are to be processed at the central landing to which the full trees are brought, the operators will be forced to find ways of dealing with the mountain of branches, leaves, needles and perhaps bark which will quickly be under foot. And, since the wood will all be concentrated at that point, what would be more logical than to process and utilize some for power, as the Russians already do, and to send the rest along, still in a concentrated form, by some means of continuous flow such as is afforded by a pipeline?

Research Projects

The challenge of full-tree logging has been taken up at the Pulp and Paper Research Institute in Montreal.[2] A small task force of design engineers are at work evaluating the complex of new equipment that will be needed to do a complete job of full-tree logging and full-tree utilization, including the central processing plant. This sort of thorough analysis, of course, should precede design of individual units. Also, before they spend large amounts on development of individual vehicles for transportation from the landing to the mill, they are taking a good careful look at a comparative economics and some aspects of the technology of pipeline, monorail and cableway.

When these painstaking analytical studies have been completed, a very comprehensive program of experimental work and design probably will get under way. They will be calling for strong support in dollars and for the help of people in the equipment business, and maybe in the pipeline field. Meanwhile, here and there around the world, companies have been trying out full-tree methods, and the Russians have applied them rather broadly. But all of these efforts have been crude and inefficient because the right equipment to do a really efficient job does not yet exist.

[2] Koroleff, Alexander. 1954. Full-tree logging —a challenge to research. Pulp and Paper Research Institute of Canada. Montreal.

Much more attention has been given to the liquid residues from chemical pulpmills than to the far more abundant solid wastes in the forest. This is partly because, until rather recently, not much research attention of any kind was centered on the forest in North America. And it is partly because the public relations problems generated by the liquid effluents have been a very good stimulant to research.

Plants to extract tall oil or turpentine or to make alcohol or vanillin or furfural from pulping liquors have been profitable and have supplied limited markets. What has been lacking is mass markets for large volumes of a few simple substances which can be recovered from pulpmill spent liquors. So millions of gallons are being poured on gravel highways to stabilize the soil, taking with them irretrievably a large fraction of the inorganic chemicals used in the pulping, the sulphur and the alkali.

One reason for the rapid spread of the kraft process, aside from its suitability to the cooking of more species and the great strength of kraft paper, is the recapture of cooking chemicals and heat in the recovery furnace. Here, then, is a perfect example of mass markets for a few simple chemicals, right at home in the pulpmills themselves.

Unfortunately, as yet no similarly economic recovery process has been found for sulphite and semi-chemical mills. Perhaps one reason for this has been an improper approach to the problem by the research men. The literature contains thousands of references on waste sulphite liquor utilization. Many of them describe the processing of only a fraction of the total effluent, through a sequence of intricate organic reactions, to extract a very small quantity of some exotic chemical for which there is only a microscopic or non-existent market.

The work was excellent—thorough, complete, and costly. Someday it may prove very valuable indeed. But meanwhile, it is collecting dust on the shelves of the library. And, although so very much effort has been spent on the organic chemistry of pulpmill liquors, relatively little is yet known about the physical chemistry of the lignosulphonic acids and the lignosulphonates, their precursors, associates and derivatives. Yet it is the physico-chemical characteristics of these substances which may have the most to do with the uses to which they can be put. Thus, there are at least two respects in which it would appear that the research effort has been largely misdirected for some 30 years or more, if the objective was to get a recovery plant into being.

Atomized Suspension Technique

At the Institute in research began about five years ago to seek a simple method of treating the entire spent liquor stream for recovery, at first, of only the inorganic chemicals and the heat. In doing so a drugstore full of potentially very valuable organic compounds might be discarded or destroyed, just as is done in the kraft recovery furnace. If such a method could be developed successfully so that sulphite and semi-chemical mills could reduce pollution, recapture and re-use the sulphur and the alkali which they have been sending down the drain, and get a dividend in process steam or heat, such plants would multiply. Thereafter, plenty of money might be received for research to modify the new process in order to recover additional values from portions of the effluent stream or of the process products. Moreover, this would have the advantage of not plunging the industry too suddenly into the chemicals producing and marketing field. A few companies have stepped boldly into that circus with both feet in recent years; but the pulp producers are generally most reluctant to enter such a fast-moving, competitive arena.

This approach to the problem has paid off. Chemical engineers have come up with what promises to be a real breakthrough, not only in pulpmill recovery but also in treating a wide variety of effluents, including sanitary sewage, and in many other fields of industrial processing, from the roasting of sulphide ores to the drying is called the "Atomized Suspension Technique" or "AST". It has been acclaimed[3] as a new unit operation in the whole field of chemical engineering because of the great range of processes to which it may be applied. The industry has spent about $750,000 on the development so far; and AST has been protected with patent applications in 17 countries. Until patents have been granted wide publicity has not been given to the details of the technical know-how acquired over these five years.

Commercial Applications

The promise of commercial success in this work is such that a task force

[3] Anon. 1955. Editorial. Chemical Engineering. Dec.

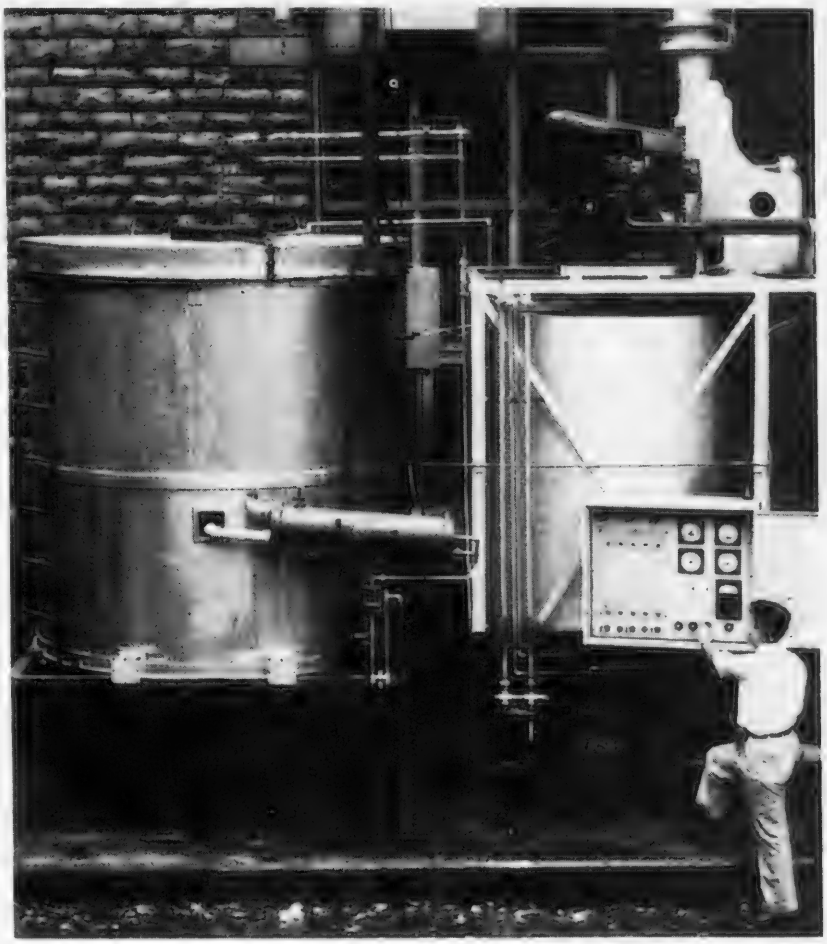


Fig. 1.—The Pulp and Paper Research Institute's portable AST demonstration plant used to study AST application to sludges and slurries.

of seven professional engineers are working on AST, three of them Ph.D.s. And already, five prominent engineering firms which design and build chemical plants all over the world are working closely to become knowledgeable about AST so that they can offer their customers plants incorporating this method. Even though there is not yet anywhere an AST plant which can handle more than the small experimental equipment (gallons per hour), these firms are beginning to invest substantial amounts of their own money, in order to be first with the new technology.

A 50-ton-per-day plant for recovery of soda liquor by AST from a pulpmill in Scotland should be under construction shortly. A flow-sheet for recovery of pickling liquors from steel mills has been designed and probably will soon be converted to a pilot-scale plant. A commercial plant for treating an ore slurry in the British West Indies is under consideration. A demonstration of the use of AST for the destruction of the sanitary sewage sludge in a community of 10,000 population is expected by the end of the summer.

A study has been made of the application of AST to chemical recovery from sulphite pulping liquors of calcium-, ammonium- and sodium-base, from kraft, from soda and from neutral sulphite semi-chemical (NSSC) liquors. Slurries from a vanillin plant, a hardboard plant, an ammonia plant, an aluminum ore plant, and a vitamin production process also have been treated. The possibilities of treating the slurry from the centricleaners of a pulpmill to recover heat for additional process steam was studied. Pulverized bark was converted into a powdered carbon in three seconds. A heat-sensitive pharmaceutical was evaporated and dried in a single pass through one piece of apparatus, whereas now two steps in separate equipment are required. A uranium ore solution was put through a continuous sequence of six steps which are now carried out batchwise in seven hours; and these six steps were completed in a single flow through experimental equipment which took slightly less than seven seconds.

Operation of AST

How does this atomagic work? To describe its use in the many applications studied thus far would take hours. But a generalized picture of the atomized suspension technique and some idea of its use for recovery of chemicals and other values from pulpmill effluents can be given.

Like many inventions of commercial value, the AST is so simple that

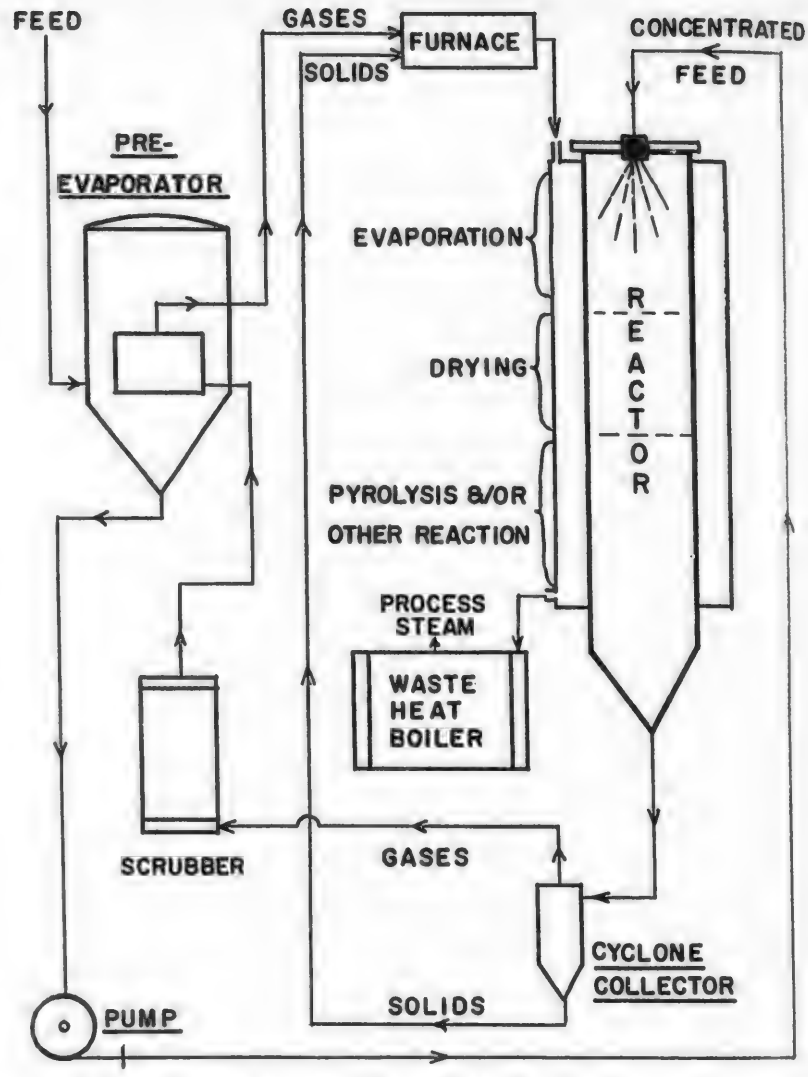


Fig. 2.—Generalized flowsheet for the Pulp and Paper Research Institute's Atomized Suspension Technique.

several engineers are kicking themselves because they didn't think of it first. Also, like many inventions on which patents are granted, it may sound very much like something which has already been conceived and published, or which is in commercial use. But the Institute is confident of its novelty. And it has been able, so far, to demonstrate this to patent offices across the world.

The atomized suspension technique consists of atomizing into the top of a single empty tube a cloud of the solution or slurry to be treated. The walls of the tube are kept at a temperature up to 1,500° F. Under these conditions, the moisture in the feed liquid is flashed at once into superheated steam. And this becomes the medium of downward transport of the now thickened droplets. No foreign gas is introduced into the system, as is the case in spray-drying and in fluidization. Hence, there can be no film of foreign gas absorbed on each droplet to interfere with heat transfer and chemical reaction. Therefore, further evaporation, drying, and finally chemical treatment will proceed at rates at least three times as fast as they would in a fluidized system.

The cloud of droplets suspended in superheated steam moves down the reactor in simple, essentially nonturbulent flow. If the atomizing spray does not intersect the hot walls before the droplets have reached their terminal velocities, the evaporating and drying droplets will not touch the walls and will, indeed, be repelled from them, just as is a water droplet dancing on a hot stove. Hence, there can be no scaling and no corrosion of the equipment by contact with wet, hot acid or alkali.

In a few seconds, the thickened droplets are completely evaporated and dried. There is then, a suspension of dry, solid particles in a vapor of

their own creation, moving rather uniformly through the reactor.

Reactant gases or powdered catalysts introduced into the reactor below the zones of evaporation and drying (or lower) will not diffuse upward. They will be carried along by the atomized suspension to do their work and to disappear.

As the dried solid particles in a cloud of superheated steam move down the reactor they may become subject to pyrolysis; i.e. thermal decomposition in the absence of air or oxygen. When the feed to the reactor is a pulpmill liquor, a whole menagerie of combustible and non-combustible gases will be driven off the solid particles to mix with the steam—methane, hydrogen, ethylene, carbon monoxide, carbon dioxide, and various illuminants. These gases may be burned to provide heat to the reactor walls. And, if the BTU content of the liquid feed to the reactor is high enough (as it is in most pulpmill effluent cases studied), the whole process becomes self-sustaining as to heat, once it is in operation. Moreover, the reactions are strongly exothermic—i.e., they give off heat. Thus, there is an excess credit of BTUs under these conditions.

As the gases are evolved, the dried particles acquire an increasing content of carbon.[4] And they contain the non-volatile inorganic chemicals present in the pulpmill liquor—sodium, or calcium, or magnesium, and so on.

The suspension is then separated. The dry carbon residue is pulled out by cyclones. The gases are sent along to be burned to provide the heat for the reactor and the heat for operating a preliminary evaporation step to increase the solids content of the feed to the reactor. The steam may be condensed for re-use of the process water it represents (a feature of the AST which may be of major significance in some localities); or it may be used as additional process steam somewhere else in the mill; or it may be converted to electric power.

The carbon residue may be burned to yield additional heat and to leave the inorganic chemical in the ash. Or, if the alkali is a soluble one like sodium carbonate, this can be leached out with hot water before the burning.

Sulphur comes out as a gas, either as hydrogen sulphide or sulphur dioxide, and can be recaptured readily. If the liquor is from an ammonium-base sulphite plant, the ammonia also is evolved as a gas in the reactor and the ammonia and sulphur dioxide are removed in an absorber and are made up again into ammonium bisulphite. The carbon in this case has a very low ash and sulphur content and may be of interest for metallurgical purposes.

Thus, the atomized suspension technique is a process which can convert a pulpmill liquor into useful steam, combustible and non-combustible gases, and solid carbon particles containing recoverable chemicals, all in less than half a minute. Since it is a closed system, heat losses are nominal. The reactor is of simple design, and the other components of the recovery plant, cyclones, atomizing nozzles, condensers, gas absorbers, etc., are well-proven, standard, commercial equipment. Economic analyses based on work thus far show that total capital plant costs may be amortized in 15 to 30 months before taxes.

In the years ahead, much more will be heard about AST and its use in dealing with the garbage of many industries. Word that ways have been found of using it right in the woods to convert bark and waste wood to power also might be heard. And a way of making pulp in the reactor might even be discovered. The name of our Dr. William H. Gauvin, the inventor of AST, will come down in the annals of industrial processing along with those of such people as Frasch, Fourdrinier, Mitscherlich and Houdry. Though was given of calling the process "gauvinizing", but it was decided to let industry users find some name that would be less a jaw-breaker than "atomized suspension technique".

Odor Control

Now the discussion comes to the least important effluents of industry from an economic point of view—the smells. This is a field in which minute quantities can have tremendous consequences. And, although an odor may represent an economic loss, to remove it completely may cost far more than any values recovered, or may be absolutely prohibitive.

Over the centuries the ingenuity of man in dealing with the problem of an unpleasant smell has been remarkable. The techniques he has devised have come down from generation to generation. Among them we can distinguish the following:

1) The Let's Pretend-It-Isn't-There-Technique: This is known, for short, as the LPIITT. It probably dates back to the Stone Age when a reeking hunter, all sweaty and spattered with mammoth blood, returned to his cave and answered the protests of his offended mate with the caveman equivalent of—"Why, my dear, I can't smell a thing . . . .You have the damnedest imagination!"

2) The Substitute-Something-Quickly Process: This is a legacy from the lords and ladies of Britain who when they went visiting the slum areas of London, held a nosegay of roses or carnations close to their nasal probosci to keep from smelling the populace. But, think of the florists' bills, if this method were to be adopted by the myriad residents of Chicago within smell-shot of the abattoirs, or by the twenty-five million drivers who annually cross the Jersey meadows on the new high-speed turnpike!

3) The Ya-Just-Gotta-Get-Used-To-It Conclusion: This is, of course, the least desirable of the techniques. It is adopted to cover feelings of frustration because the research boys have not yet come up with something promising; so, the employment office says, "Ya want the job, or doncha?"

4) The Block, Absorb or Destroy It Commercial: Liquids, pastes, creams and sprays to do this kind of job when applied to one's person are so well known through modern magazine, radio and TV advertising that there is no need to comment on this evidence of man's awareness of the importance of his social acceptability. But it is interesting to contemplete how the world got populated so abundantly through the ages when these drugstore staples were not available.

5) The Mixed Stinks Method: Cosmeticians say that the way to get a really alluring new perfume is to mix together substances which, sniffed separately, have the vilest odors known. Just the right combination of these stinks will produce such heavenly fragances as lily-of-the-valley or lilac, although the components which combine to make the perfume may never even have been near a garden. The deception practiced by these affluent merchants is well worth noting. Hence, it be worthwhile to promote among chemists the idea of combining the smells of a chemical pulpmill with some other horrible odor to produce effluent perfumes. Then one of the mill towns will be able to advertise that it is "the gardenia community of North America", or "the heliotrope centre of the Continent". This would be turning a problem to advantage; but would, of course, be only a temporary palliative to give the research boys more time to find the ultimate solution when our industry will be utilizing everything, including the smell.

[4] This part of the process is analogous to the formation of coal from peat and lignite under the dynamic pressures and thermal decomposition which occur in Nature to drive off the moisture, the oxygen and the more volatile hydrocarbons and to increase the fixed carbon content of the material.

The Penetration of Light into Wood

F. L. BROWNE
and
H. C. SIMONSON

Chemists, Forest Products Laboratory[2], Forest Service,
U. S. Department of Agriculture

Four different methods were used to measure penetration of light into wood. Ultraviolet light has little penetration; visible and infrared light penetrate roughly in accordance with Beer's law. Extinction coefficients seem to run parallel to amount of color in wood.

Introduction

IN THE COURSE OF A STUDY of the changes in wood caused by exposure to the weather, it became desirable to learn how far sunlight penetrates into wood. In strong sunlight, the surface of wood begins to change in color toward a deeper brown (5, 6)[3] within a few minutes. (Some woods strongly colored by extraneous constituents may bleach at first, but the browning becomes evident later on.) Similar browning occurs at a much slower rate in the more subdued light within buildings, where the ultraviolet components of unfiltered sunlight are lacking. Well-weathered wood acquires a layer, gray in color and about 0.005 inch thick, of loosely matted, largely delignified, cellulose fibers contaminated with dirt, mold spores, and pollen that appear gray in color. Beneath the gray layer is a well-browned layer from 0.02 to 0.1 inch thick in which the orderly structure of normal wood is retained, but the content of water-soluble extractives of decidedly brown color is greater than normal and the ligneous middle lamella is especially deeply browned. Below the brown layer, the wood remains essentially unchanged. Wood weathered high in the mountains turns brown but often lacks the gray layer, possibly because precipitation there is largely snow, which lacks the ability of rain to leach the solubilized decomposition products of lignin (3).

Browning may well be a preliminary step in the process of wood weathering. The browning has been considered an oxidation of lignin to humus or humic acid (1, 4, 6), in which ultraviolet light plays a necessary part (2) or is at least strongly stimulating. A reasonably close relation between the depth to which light penetrates wood and the depth of the browned layer of well-weathered wood might then be expected, unless brown material actually formed nearer the surfaces migrates deeper into the wood in some way.

Schramm (5) reported that light acts on wood chemically to a depth of 0.1 to 0.25 millimeter (0.0039 to 0.0098 inch), but failed to tell how the measurement was made. The browned layer of weathered wood is two to ten times as deep. It was therefore of interest to make new measurements of the depth of penetration of light of different wavelengths into wood.

Materials and Methods of Test

Four distinctly different methods were used to measure the transmission of light through wood. It was not necessary to distinguish between

[1] Part of a cooperative project with E. I. du Pont de Nemours & Co., Marshall Laboratory.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to Literature Cited.

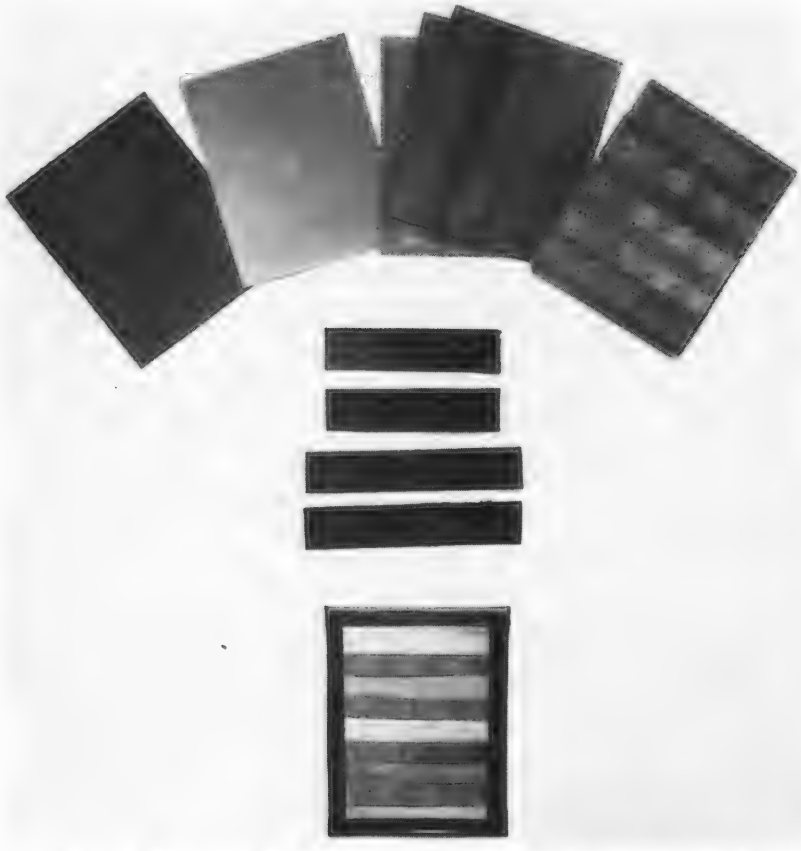


Fig. 1.—Black paper, film, build-up layers, stepped overlap and tape used in preparation of final assemblies for photographic exposures.

The Authors: F. L. Browne did undergraduate work in chemistry at Cornell and received a Ph.D. in colloid chemistry from Wisconsin. He joined the Forest Products Lab staff in 1918. In 1921-22 he was a National Research Fellow at Wisconsin. Dr. Browne is a frequent contributor to the *Journal*, and since 1929 has edited the general and physical chemistry section of *Chemical Abstracts*.

H. C. Simonson received B.S. in Chemistry from University of Wisconsin in 1952. He was engaged in synthesis of pesticides with Ethyl Corporation, Detroit, before serving two years in radiobiology with Army Medical Research Laboratory, Ft. Knox. With the Forest Products Laboratory since 1956 he has served as chemist in the Division of Timber Processing.

light absorbed by the wood and that reflected from it. The first method was a photographic one in which the relative density of silver deposit developed in a photosensitive film was measured after exposure to the light transmitted through successively increasing thickness of wood. The second was a photovoltaic method in which the light transmitted through wood was measured by a calibrated photovoltaic cell. The third and fourth were spectrophotometric methods in which the spectrum of transmitted light was measured. The woods studied were western larch, redwood, ponderosa pine, and ponderosa pine that had previously been browned in artificial sunlight.

Photographic Method. In total darkness, an assembly illustrated in Fig. 1 was prepared as follows. A 4- by 5-inch sheet of black paper was laid down, and a 4- by 5-inch photographic film, Kodak Royal Pan, placed over it with the emulsion side up. The film was then covered with 19 pieces of sliced, edgegrain western larch veneer, each 4 inches wide and 0.01 inch thick, laid one after another as illustrated. The first 11 pieces were each 5 inches long, and each succeeding piece was about 0.5 inch shorter than the one before so that a progression in thickness of wood from 0.11 to 0.19 inch in steps of 0.01 inch was produced. In the pile of 19 pieces, the grain directions of adjacent pieces were at right angles to prevent any possible alignment of summerwood bands in the veneer. The entire assembly was held firmly together with opaque, black pressure-tape applied along the edges, and was then inserted in an opaque envelope to exclude light except during the desired period of exposure.

The assembly was exposed by holding the wood side facing the flaming carbon arc with Corex–D globe of an Atlas Weatherometer for exactly 1 minute at a distance of approximately 1 foot from the globe. The assembly was then taken apart in darkness and the photographic film was developed according to the recommendations of the maker. A negative of graded density was obtained in which each step in film density represented the relative intensity of light that penetrated the number of pieces of veneer over it. Several observers then read the density of each of the nine steps of density in the negative by means of a Kodak Densigui le.

The readings of the several observers for each of the nine steps in density, which agreed closely, were averaged. The film density, which corresponds to the logarithm of the relative exposure, was plotted against the veneer thickness to determine a coefficient of extinction according to Beer's law.

Photovoltaic Method. Fig. 2 shows the arrangement for the photovoltaic method. A General Electric model 8PV 2FAA photovoltaic cell was connected to a 100-ohm microammeter of range 0 to 50 microamperes to read directly the light transmitted through various thicknesses of veneer placed over the face of the cell. The source of light was a tungsten lamp hung four feet above the face of the cell. The intensity of the light could be varied by adjusting the supply of electricity with a variable transformer.

With the face of the photovoltaic cell uncovered, the tungsten lamp was adjusted to provide light enough to bring the microammeter to a prescribed reading of 40 microamperes. One or more layers of wood veneer of the desired kind and thickness were then placed over the face of the cell and readings of the microammeter were recorded. The transmission through each veneer sample was determined three times, and the light source was adjusted to a reading of 40 before each determination. The maker of the photovoltaic cell provided a calibration chart to convert readings in microamperes to percentage of light transmitted.

By this method, transmission was observed through western larch from the same flitch used for the photographic method but in veneer 0.007 inch thick, and through ponderosa pine and redwood veneer 0.008 inch thick. (The redwood veneer was carefully selected from thin pieces cut in a planer. The pieces ranged from 0.005 to 0.020 inch in thickness.) Also tested was ponderosa pine veneer 0.008 inch thick that was deeply browned by exposure for 15 days (7½ days on each side) to a flaming carbon arc with Corex–D globe.

Fig. 2.—Photovolatic cell connected to micrometer, microammeter, and the tungesten light source with variable transformer. Specimens were placed horizontally over the cell for transmission measurements.

Spectrophotometric Methods. A spectrophotometer was necessary for more complete analysis of the spectral transmission through wood. There was available a Beckman DK–2 ratio-recording instrument shown in Fig. 3.

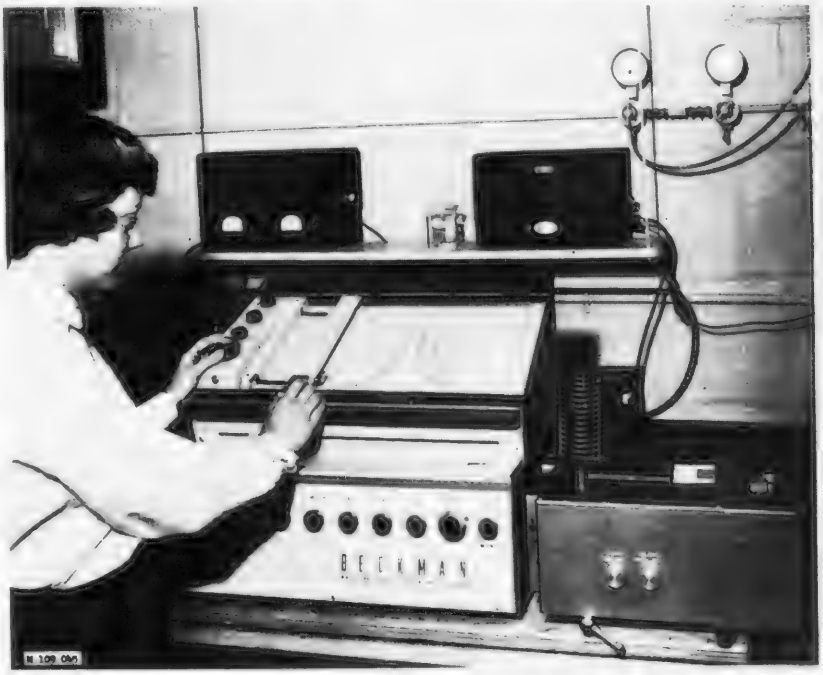


Fig. 3.—DK-2 Ratio-Recording Spectrophotometer showing total energy curves (Fig. 5), and filter paper diffuser and sample specimen beside the sample holder.

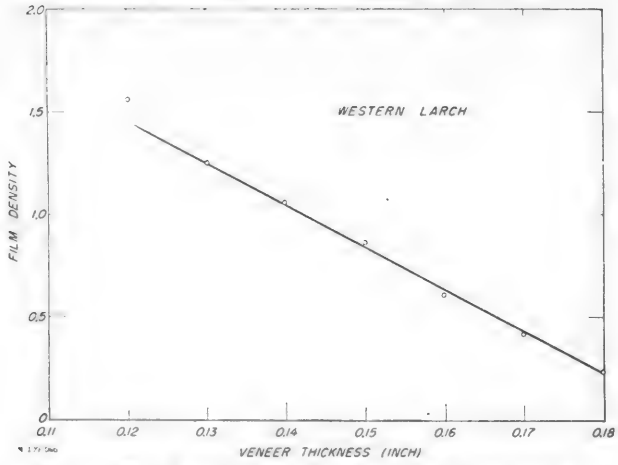


Fig. 4.—Film density resulting from exposure to light through increasing layers of western larch veneer.

Light from a suitable source is passed through a slit of adjustable width that determines the amount of light to be admitted. From the slit the beam of light is directed to a reflecting prism, where it is spread into a spectrum of monochromatic wavelengths that are then returned one after another through the slit to a sample chamber. Here the monochromatic beam may be directed alternately along a reference channel and along a sample channel; the sample whose transmission is to be observed is placed in the sample channel. The beam emerging alternately from the reference channel and the sample channel is directed to the detector to measure its energy. The instrument scribes a chart that records the energy received at each wavelength of the spectrum through the reference channel and then through the sample channel.

The instrument can be operated to record either the total energy received at each wavelength or the per cent of the incident light of each wavelength transmitted through the sample. For total energy, the slit is set permanently in a suitable open position, the ratio-recording mechanism is inoperative, and the sample channel only is used. The spectrum of the light source is recorded, then the sample is inserted and the spectrum transmitted through it is recorded. To record per cent transmission, both channels are used and the ratio-recording mechanism causes the slit to vary in width according to the energy emitted by the source so that the beam through the reference channel has uniform energy throughout the spectrum (within the limits of sensitivity of the detector). The chart for the beam through the sample channel then reads directly in per cent transmission.

First efforts to measure the per cent transmission through 0.01-inch wood veneer placed in the customary position where the sample beam enters the sample chamber indicated transmission far below the 1 per cent of the reference beam that can be detected by the instrument. Nevertheless the monochromatic beam striking the veneer appeared brilliantly on the rear surface of the veneer. It was therefore evident that the collimated beam became so diffused by passage through the wood that only a small fraction of the transmitted light reached the detector. Rough calculation revealed that, if uniform diffusion is assumed for the light into the 180° solid angle about the point of emergence from the veneer, less than 0.1 per cent of the emergent light would strike the mirror for reflection to the detector.

The difficulty was overcome by diffusing the light equally in both the reference beam and the sample beam. Even with the intensity of the light reaching the detector reduced by such diffusion, enough light was available in both reference beam and sample beam for proper functioning of the instrument. A piece of Whatman No. 52 filter paper served satisfactorily for the diffuser. One or more samples of wood veneer were then placed in the sample channel. The idea of diffusion by filter paper was applicable in similar fashion to measurement of total energy. The procedure is believed to yield satisfactory results for the purpose, even though it is not certain that the diffusion pattern remained the same for increasing thicknesses of veneer.

For the spectral range below 400 millimicrons wavelength, the light source was a mercury-vapor lamp and the detector was a photomultiplier. For the range 400 to 735 millimicrons, the light source was a standard tungsten lamp and the detector was the photomultiplier. For the range 735 to 2,450 millimicrons, the light source was the tungsten lamp and the detector was a lead sulfide cell.

The veneer specimens examined by the spectrophotometric methods were the same ones that were observed with the photovoltaic cell. Samples for the spectrophotometer were about 1 inch square.

Results and Discussion

The results obtained by the four methods furnished the desired information about the penetration of light into wood.

Photographic Method. In fig. 4, the film density is plotted against the thickness of western larch veneer through which exposure was made. The densities reported are averages of duplicate tests.

Within the latitude of the photographic film, the photographic density obtained decreased nearly linearly with increasing thickness of veneer through which the exposure was made. (The thinnest and the thickest layers of veneer in the assembly gave exposures beyond the latitude of the film.)

The density of a photographic film exposed for a given time is proportional to the logarithm of the amount of light that reaches the film. Fig. 4 then shows that the logarithm of relative intensity of transmitted light decreased with increasing thickness of veneer. The results therefore mean that light penetrates wood in accordance with Beer's law, which for this purpose, may be written

$$\log \frac{I_0}{I} = Kt$$

where I_0 is the intensity of incident light, I is the intensity of transmitted light, t is the thickness of wood, and K is a constant called the extinction coefficient. Since I_0 was not known, it was convenient to rearrange Beer's law in the form

$$\log \frac{I_1}{I_2} = K\ (t_2 - t_1)$$

which can be solved with the data of Fig. 4 to show that the extinction coefficient, K is 20. Knowing K, the fraction of the incident light that reaches any given depth or the per cent transmission for any given thickness of western larch wood can be calculated.

The extinction coefficient so measured is an average of the extinction coefficient for each wavelength of light within the broad spectrum of the light source to which the film is sensitive. The film is affected not only by its own range and degree of spectral sensitivity but also by the variable spectral emission of the light source and any variation in coefficient of

extinction of the wood according to wavelength. The light source is reported to emit half its energy in the range between 400 to 700 millimicrons, the approximate range to which the film is said to be sensitive.

Photovoltaic Method. The photovoltaic cell has a spectral sensitivity range of 350 to 700 millimicrons, which is very similar to that of the photographic film. The cell is provided with a calibration chart to relate readings in microamperes to per cent transmission. The linear calibration chart was checked experimentally with wire mesh screens of known open area and was found to be accurate.

The transmission through western larch was 43.2, 21.0, and 9.8 per cent through one, two and three layers of 0.007-inch veneer, respectively. The coefficient of extinction from these data would be 49 for the spectral range covered. The discrepancy between this value and the value of 20 by the photographic method is discussed later in the report.

Edge-grain redwood 0.012 inch thick transmitted 7.4 per cent of the incident light. The coefficient of extinction of redwood calculated from this reading (in the photovoltaic method the intensity of incident light is known) was 109. Thus equal extinction is reached in redwood at less than half the thickness required in western larch. The dark color of redwood suggests a high coefficient of extinction.

Ponderosa pine was available in both heartwood and sapwood. In addition, specimens of both heartwood and sapwood were browned by exposure to artificial sunlight to provide material for observing the effect of browning on the coefficient of extinction. The results are reported in Table 1.

The unbrowned heartwood of ponderosa pine had an extinction coefficient very close to that of western larch. Unbrowned ponderosa pine sapwood had a lower coefficient of extinction and is also lighter in color than the heartwood. Browning materially increased the coefficient of extinction of both heartwood and sapwood, but even after browning, the coefficient remained lower for sapwood than for heartwood. The coefficient for the browned heartwood failed to reach the high value of that for unbrowned redwood (heartwood). The red color of redwood differed so much from the brown color of the pine that it was hard to say which seemed the darker by visual observation.

The photovoltaic method is subject to the same limitations as the photographic method. The photovoltaic cell, like the film, has a limited range of spectral sensitivity, and the sensitivity for different wavelengths is not uniform. The tungsten lamp, like the carbon arc, has its own variable pattern of spectral emission. Because of these limitations, no more than an approximate correspondence between the results by the two methods can be expected, and the limitations must be kept in mind in applying the data to other light sources. For a more precise understanding of the subject, a spectral analysis of the transmission of light through wood is necessary.

Spectrophotometer Method by Total Energy. Fig. 5 shows the spectra of the light source and of the light transmitted through one and through two 0.007-inch thicknesses of western larch veneer for the range of wavelengths from 550 to 2,400 millimicrons. Visible light consists of the range from 400 to 750 millimicrons, ultra-violet light in sunshine reaching the earth ranges from about 280 to 400 millimicrons, and infrared light in sunshine ranges from 750 to 3,000 millimicrons. In Fig. 5, the rapid decline in energy below 800 millimicrons is due to lack of sensitivity of the lead sulfide detector, not to absence of shorter wavelengths in the tungsten light source or in the light transmitted through the veneers. The detector also lacks sensitivity beyond about 2,000 millimicrons.

The area under a curve between any two wavelengths represents the total energy of light transmitted in all wavelengths between the limits chosen. For preliminary measurements, the areas under the curves between 800 and 2,000 millimicrons were determined with a planimeter. Such calculations indicated that 70 per cent of the incident light was transmitted through 0.007 inch of larch veneer and 50 per cent through 0.014 inch. Since the scale of wavelengths on the spectrophotometer is not linear, it was felt that the areas measured by planimeter might not be truly representative. Accordingly, further calculations were made in which the areas under the curves were based on the average levels at intervals of 50 millimicrons across the spectral range recorded. The results were the same as those obtained by planimeter.

The data of Fig. 5 indicate an extinction coefficient of approximately 22 for western larch, which agrees closely with the determination by the photographic method.

Spectrophotometer Method by Per Cent Transmission. The per

Table 1.—COEFFICIENT OF EXTINCTION AND PER CENT TRANSMISSION BY THE PHOTOVOLTAIC METHOD

Ponderosa pine wood	Coefficient of extinction	Light transmission through veneers	
		0.01 inch thick Per cent	0.02 inch thick Per cent
Heartwood, not browned	46.9	31.1	13.1
Heartwood, browned	74.1	16.3	4.1
Sapwood, not browned	41.1	37.0	16.5
Sapwood, browned	65.5	20.0	6.0

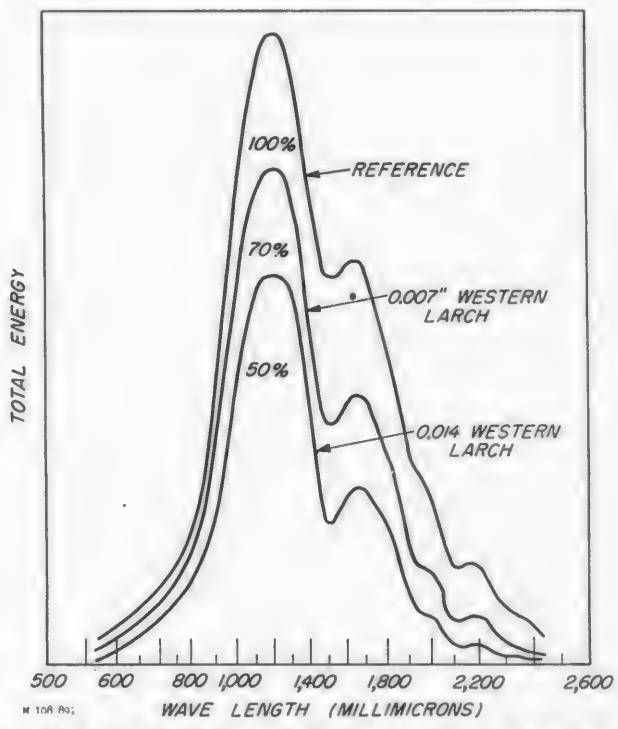


Fig. 5.—Total energy output of the tungesten lamp recorded with a filter paper diffuser as reference and with one and two layers of 0.007-inch western larch veneer as the sample. A lead sulfide detector was used over the entire range.

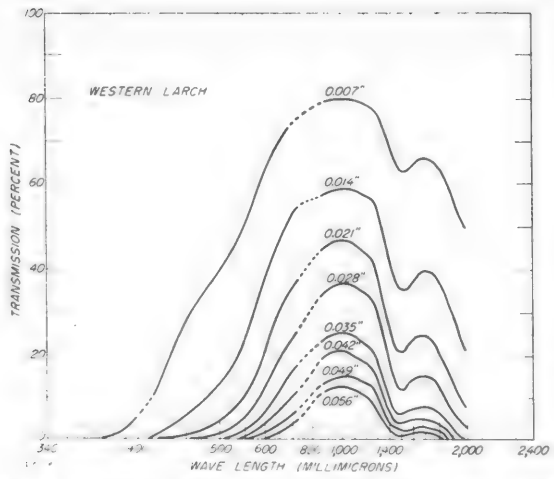


Fig. 6.—Composite transmission curve for western larch covering three spectral ranges. Broken lines that join the separate curves were not obtained experimentally. Veneer thickness through which the transmission was measured is indicated above each curve.

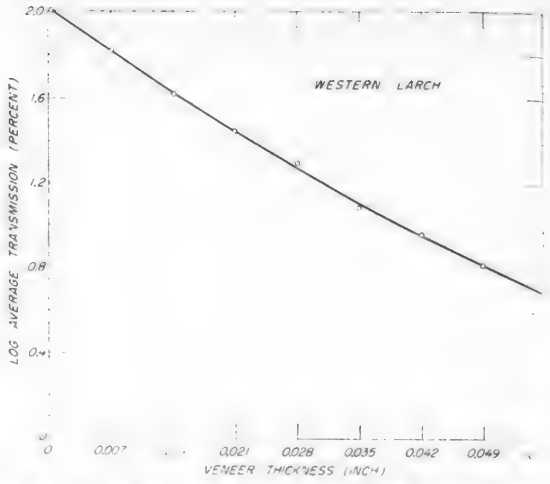


Fig. 7.—Log of average transmission through western larch from Fig. 6, against corresponding veneer thickness.

cent transmission through western larch, ratio-recorded over the range 370 to 2,000 millimicrons, is given in Fig. 6. The regions from 370 to 400, 410 to 735, and 850 to 2,000 millimicrons, which are shown in solid lines, were recorded with different combinations of light source and detector, and the curves are joined arbitrarily by dotted lines. The transmission in the ultraviolet region (below 400 millimicrons) proved negligible, as Fig. 6 shows, and is therefore omitted in subsequent figures. (Veneers much thinner than those used cannot be cut practicably because they would be below the diameter of such wood cavities as resin canals in softwoods and pores in hardwoods.)

For the entire range from 370 to 2,000 millimicrons, the average coefficient of extinction for western larch was 25.5. In Fig. 7, the logarithm of the per cent transmission, averaged for all wavelengths, is plotted against the thickness of veneer. The best straight line through the points would have the slope 25.5. In reality, however, conformity to Beer's law is approximate only, and the smooth line joining the points in the graph has a slight but definite curvature. Within the moderate range of veneer thicknesses of interest in this study, the extinction coefficient may be taken as the slope of the best straight line through the points, but the results should not be extrapolated to much greater thicknesses of wood. The departure from Beer's law may be explained by the theory that a substantial part of the untransmitted light was reflected, and that only transmitted light could be expected to conform to Beer's law.

The transmission curves and the logarithms of average transmission for different thicknesses of veneer are reported for ponderosa pine, ponderosa pine browned by artificial sunlight, and redwood in Figs. 8 to 13, inclusive. The extinction coefficients for the range 400 to 750 and the range 400 to 2,000 millimicrons wavelength calculated from the data appear in Table 2.

Table 2.—COEFFICIENTS OF EXTINCTION BY THE SPECTROPHOTOMETRIC METHOD

Kind of wood	Coefficient of extinction: 400 to 750 millimicrons wavelength	Coefficient of extinction: 400 to 2,000 millimicrons wavelength
Western larch	38.0	25.5
Ponderosa pine	46.9	25.6
Browned ponderosa pine	63.6	27.1
Redwood	92.0	34.1

For the whole range of visible and infrared light, the extinction coefficients for the woods studied varied only from 25.5 for western larch to 34.1 for redwood. The differences among the woods occur chiefly in the visible range, for the transmission levels in the infrared were very simi-

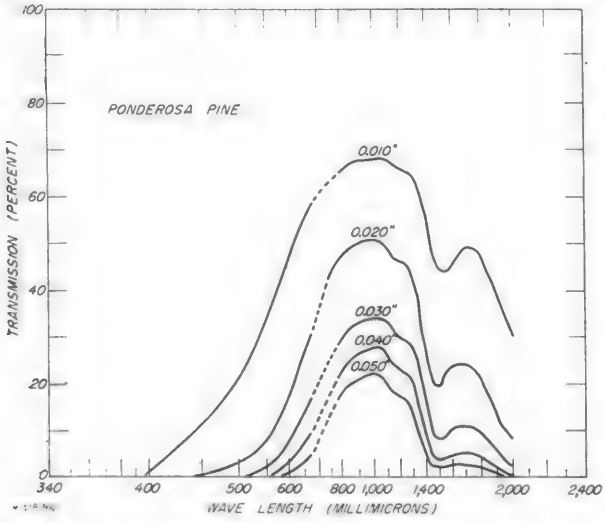


Fig. 8.—Composite transmission curve for ponderosa pine covering two spectral ranges. Broken lines that join the separate curves were not obtained experimentally. Veneer thickness through which the transmission was measured is indicated above each curve.

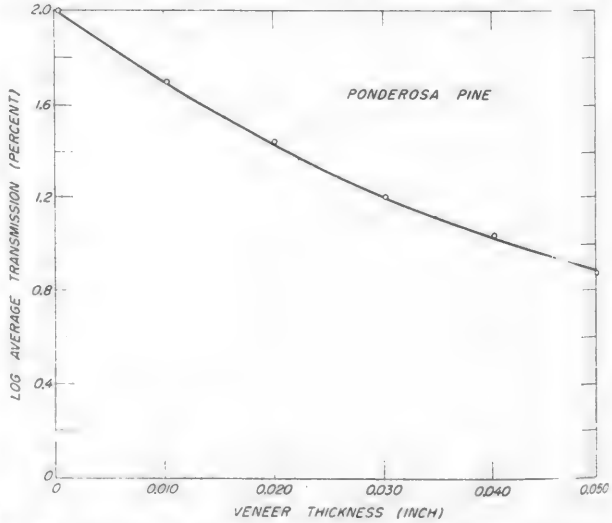


Fig. 9.—Log of average transmission through ponderosa pine from Fig. 8, against corresponding veneer thickness.

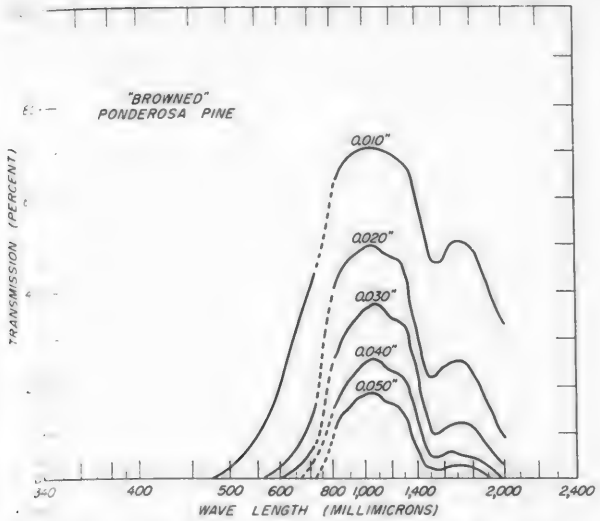


Fig. 10.—Composite transmission curve for browned ponderosa pine covering two spectral ranges. Broken lines that join the separate curves were not obtained experimentally. Veneer thickness through which the transmission was measured is indicated above each curve.

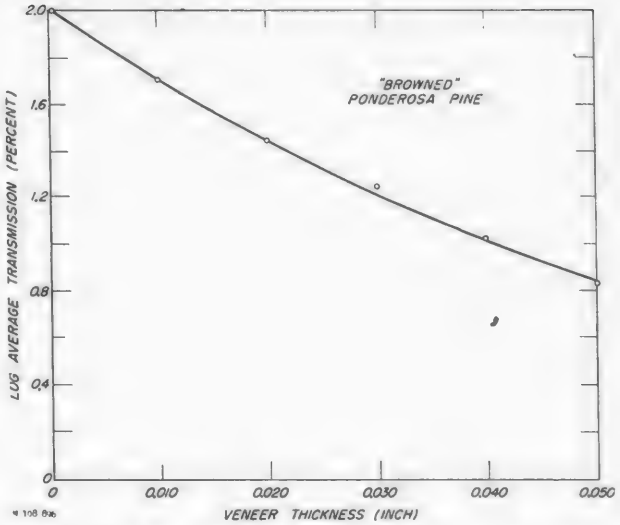


Fig. 11.—Log of average transmission through browned ponderosa pine, from Fig. 10, against corresponding veneer thickness.

lar. For the visible range, 400 to 750 millimicrons, the extinction coefficients varied from 38.0 for western larch to 92.0 for redwood. Browning increased the extinction coefficient of ponderosa pine in the visible range from 46.9 to 63.6, which was still well below that of redwood.

Comparative results by the four methods of measurement are given in Table 3 for the per cent transmission through three thicknesses of western larch veneer. The two spectrophotometric methods agreed satisfactorily with each other and with the photovoltaic cell method when the range of wavelengths effective in the measurements is considered. Transmission was clearly greater for infrared than for visible wavelengths.

Results by the photographic method were more similar to those by the spectrophotometer than for the larger range of wavelengths including the infrared rather than to the spectrophotometric results for the visible range only. Sensitivity of the photographic film to infrared was not expected. The maker of the film indicated that there may be slight sensitivity of the film to infrared on prolonged exposure (the exposure was one minute for these tests). More than slight sensitivity to infrared would be necessary to account for the results entirely on that basis. The agreement of the photographic method with the spectrophotometric method with light that includes the infrared wavelengths cannot be explained at present.

The brown layer measured in well-weathered woods of a number of species was found to be at least 0.02 inch and sometimes more than 0.1 inch thick. It is therefore of interest to calculate the per cent of incident sunlight that can penetrate to such depths on the basis of the extinction coefficients recorded in Table 2. Such calculations are given in Table 4. A depth of 0.02 inch is within the limits of validity of the extinction coefficients in Table 2, but extrapolation to 0.1 inch involves some uncertainty. The uncertainty, however, cannot be of the magnitude that certain discrepancies in the calculations reveal.

The penetration of ultraviolet light of wavelengths shorter than 400 millimicrons has been shown to be negligible. According to Table 4, 17.4 per cent of visible light (400 to 750 millimicrons) incident on the surface of western larch penetrates to a depth of 0.02 inch, but only 0.016 per cent penetrates as far as 0.1 inch. In redwood, only 1.5 per cent of visible light reaches as far as 0.02 inch, and the amount that penetrates 0.1 inch is a negligible 6×10^{-8} per cent. Yet the clearly browned layer in samples of weathered redwood measured at the Forest Products Laboratory was between 0.07 and 0.09 inch thick.

In fresh ponderosa pine, only 2×10^{-3} per cent of visible light penetrates as far as 0.1 inch, but as soon as the wood has become browned the penetration at 0.1 inch drops to 4×10^{-5} percent and wavelengths shorter than 500 millimicrons are lacking. When the penetration of light that includes infrared as well as visible light is calculated in similar fashion, Table 4 shows that 0.28 to 0.04 per cent of the incident light reaches a depth of 0.1 inch, and that the differences among woods both at the 0.02-inch and the 0.1-inch depths are far smaller than for visible light alone.

The results make it difficult to believe that the thickness of the brown layer in weathered wood is determined primarily by the depth of penetration of light. If it is, it would seem necessary to conclude that infrared wavelengths are more important causes of browning than visible or ultraviolet wavelengths. It seems more probable

Table 3.—PER CENT TRANSMISSION OF LIGHT THROUGH DIFFERENT THICKNESSES OF WESTERN LARCH VENEERS MEASURED BY FOUR METHODS

Thickness of layer of veneers	Transmission of light through veneers				
	400 to 750 millimicrons wavelength		400 to 2,000 millimicrons wavelength		
	Spectrophotometer, per cent transmission method Per cent	Photovoltaic cell method Per cent	Spectrophotometer Per cent transmission method Per cent	Spectrophotometer Total energy method Per cent	Photographic film method Per cent
.007	44.6	43.2	65.3	70.0	72.4
.014	20.3	21.0	41.3	50.0	52.4
.021	11.1	9.8	27.9	----	38.0

Table 4.—PER CENT TRANSMISSION* OF VISIBLE LIGHT AND OF VISIBLE AND INFRARED LIGHT AT THE UPPER AND LOWER LIMITS OF THICKNESS OF THE BROWN LAYER IN WELL-WEATHERED WOOD

Wood	Transmission of light through veneers			
	400 to 750 millimicrons wavelength		400 to 2,000 millimicrons wavelength	
	At depth of 0.02 inch	At depth of 0.1 inch	At depth of 0.02 inch	At depth of 0.1 inch
Western larch	17.4	0.016	30.9	0.28
Ponderosa pine	11.5	.002	30.8	.28
Browned ponderosa pine	5.3	.00004	28.7	.19
Redwood	1.4	.00000006	20.8	.039

*Per cent transmission values were calculated from the extinction coefficients reported in Table 2.

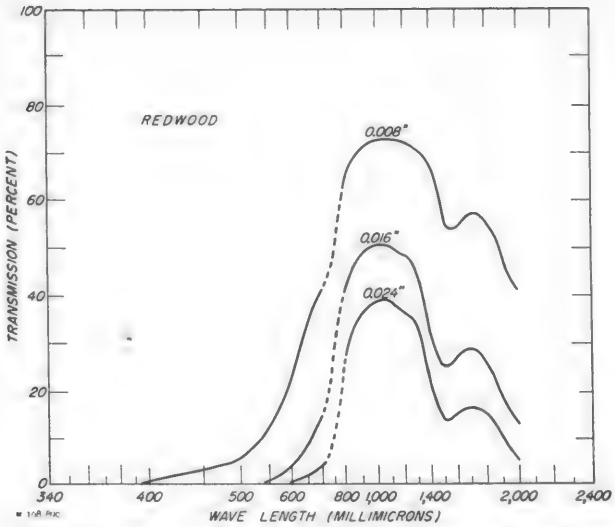


Fig. 12.—Composite transmission curve for redwood covering two spectral ranges. Broken lines that join the separate curves were not obtained experimentally. Veneer thickness through which the transmission was measured is indicated above each curve.

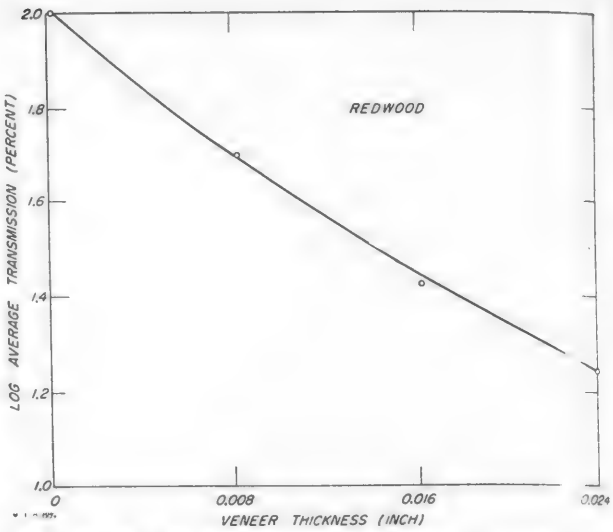


Fig. 13.—Log of the average transmission through redwood, from Fig. 12, against corresponding veneer thickness.

that the brown substances generated in wood by light are soluble in water, and that the thickness of the brown layer in weathered wood is governed chiefly by the depth to which rain water carries the brown products of light action into deeper layers of the wood not reached by light directly. A better understanding may be reached when more is known about the effect of ultraviolet, visible, and infrared light on the chemical degradation of wood, the solubility of brown decomposition products in water, and the depth to which rain water can carry soluble products into wood in natural weathering.

Conclusions

1) The penetration of light into wood can be measured by four different methods: (a) exposure of a suitable photographic film to light transmitted through layers of wood of various thicknesses and measurement of the relation between wood thickness and photographic density of the developed film; (b) measurement of the light transmitted through various thicknesses of wood with a photovoltaic cell; (c) measurement of the spectral distribution of light energy before and after transmission through wood in a spectrophotometer adjusted to measure the diffuse light passing through wood; and (d) measurement of the per cent transmission through the spectral range of wavelengths in a ratio-recording spectrophotometer modified to measure diffuse light.

2) Concordant results were obtained by the four methods, except that the photographic method unexpectedly yielded extinction coefficients for light that included infrared and visible wavelengths rather than visible wavelengths alone.

3) Penetration of ultraviolet light into wood is negligible—no more than a few mils—and is less than the thickness of the thinnest wood veneers that can be cut practicably.

4) Transmission of visible light, 400 to 750 millimicrons in wavelength, varies widely for different woods and runs closely parallel to the depth of color. Infrared light, 750 to 2,000 millimicrons, is transmitted more readily and penetrates deeper into wood than does visible light. For visible and infrared light together, 400 to 2,000 millimicrons, and presumably for the entire spectrum of sunlight, the variation in transmission among different woods is comparatively small.

5) Visible light is transmitted somewhat more readily through sapwood than through heartwood of ponderosa pine. The variation corresponds to the difference in color.

6) Light turns wood brown in color. Although browning may occur more rapidly in ultraviolet than in visible or infrared light, it occurs in visible light also. In visible light it occurs to a depth much beyond the depth of penetration of ultraviolet light. As wood becomes browned, the depth to which visible light penetrates decreases and transmission below 500 millimicrons wavelengths practically ceases.

7) Beer's law for the expression of the extinction of light as it passes through a transmitting medium may be used approximately for wood within fairly narrow limits of depth of penetration, but the law is not followed exactly because the extinction coefficient decreases slightly as depth of penetration increases.

8) If the thickness of the brown layer of well-weathered wood is determined by the depth to which light penetrates, infrared light must be an important factor in browning. Measurements show that the brown layer of weathered wood is often as much as 0.1 inch deep. Not much more than 1.6×10^{-2} per cent of visible light reaches that depth in western larch, and 6×10^{-8} per cent reaches that depth in redwood. For visible and infrared light together, however, 0.28 per cent of the incident light reaches a depth of 0.1 inch in western larch and 0.04 per cent reaches that depth in redwood.

It may be well that the brown degradation products of wood weathering are formed chiefly in the exceedingly thin surface layer of exposed wood that can be penetrated by ultraviolet light, and are then carried into the wood as far as the observed depth of the browned layer by rain water. The water could carry the solubilized products as far as the "wet line" beyond which the free water is absorbed by the wood substance. Ultraviolet light could then still be the most effective component of sunlight in the process of wood weathering.

Literature Cited

1. Bakker, H. 1937. Yellowing of wood-pulp paper. Chem. Weekblad 34:53–5.
2. Forman, L. V. 1940. Action of ultraviolet light on lignin. Paper Trade Journal *111*(21):34–40.
3. Frey–Wyssling, A. 1950. The Discoloration of unprotected wood by the weather. Schweiz. Z. f. Forstwesen 101: 278.
4. Hirschkind, W. 1932. Bleaching groundwood. Paper Trade Journal *95*(19): 31–2.
5. Schramm, W. H. 1906. The yellowing of woods. Jahresbericht der Vereinigung für angewandt Botanik 1906, pp. 11–39.
6. Weisner, J. 1864. The Decomposition of wood in the atmosphere. Sitzungsberichte der Königlich Akademie der Wissenschaft. Wien *49*:61–96.

Mechanical Properties of Red Oak Related to Drying[1,2]

ROBERT L. YOUNGS

Forest Products Laboratory,[3] Forest Service, U.S. Department of Agriculture
and Graduate Student, Yale University

The perpendicular-to-grain mechanical properties of northern red oak were investigated in tension and in compression between 80° and 180° F. and the moisture-content range 6 per cent to green. Included were static tension and compression tests and tests to determine creep and stress relaxation characteristics. Most properties were significantly affected by heating at 180° F. for 30 days.

Introduction

THE FACT THAT WOOD SHRINKS as it dries and thereby develops self-imposed perpendicular-to-grain stresses has been recognized for many years as the fundamental cause of most drying defects. These stresses develop and attain considerable magnitude even under closely controlled kiln-drying conditions. The magnitude and effect of these stresses depend on the perpendicular-to-grain strength, elastic, and rheological properties of the wood, the drying conditions to which the wood is exposed, and the length of time the wood is exposed to these conditions.

Wood does not dry evenly throughout its thickness, but develops a moisture gradient with a lower moisture content near the surface than in the interior. Since shrinkage is related to the amount that moisture content is lowered below the fiber saturation point, and because this lowering of moisture content does not take place evenly throughout the drying thickness, the result is differential shrinkage, with consequent stress development in the direction of shrinkage. The stresses thus developed consist of tensile stress in any portion of the wood that is attempting to shrink against the restraint of other portions of the wood, compressive stress in the portions of the wood doing the restraining, and shearing stress as adjacent portions of differentially shrinking wood tend to move relative to one another. The short-time strength properties perpendicular to the grain determine the instantaneous effects of these stresses.

The drying of wood is not an instantaneous process, however, and the effect of time must be considered even for woods that dry relatively rapidly. The drying time is influenced by the drying conditions and the ability of moisture to move through the drying wood. The drying time exerts a significant influence on the drying characteristics in two ways: 1) by introducing the effects of duration of exposure to heat, and 2) by introducing creep and stress relaxation effects. These latter effects, in turn, influence the shrinkage of wood and the development of plastic deformation, thus affecting the stresses developed during drying.

All parts of a drying board are thus subjected to perpendicular-to-grain tensile, compressive, and shearing stresses during the drying process, and these stresses are operative under various temperature and moisture content conditions and for various periods of time. These stresses influence and are affected by the drying process. It is readily apparent, therefore, that a knowledge of perpendicular-to-grain mechanical properties of wood under kiln-drying conditions should contribute substantially to an understanding of its drying behavior and thereby provide fundamental information on which to base drying schedule improvements.

Previous investigations by Greenhill (6),[4] Kollmann (13), Barnard–Brown and Kingston (2), and Ellwood (5) have pointed out some of the salient features of the relationship of static perpendicular-to-grain properties to temperature and moisture content. Only Ellwood, however, investigated properties in compression as well as in tension, only Kollmann investigated shearing strength associated with shear strain in the tangential-radial (TR) plane, the plane in which principal drying strains normally occur, and none of them included more than very limited exploratory tests of any phase of the time-related behavior.

[1] A condensation of a thesis submitted for the degree of Doctor of Philosophy at Yale University and published as U.S. Forest Products Laboratory Report No. 2079, which contains details of test procedure and a more exhaustive treatment of results. This work was done at the U. S. Forest Products Lab.

[2] First Place Winner in 1957 Wood Award Contest. Presented at Session IX, Wood Drying, FPRS 11th Annual Meeting, June 23-28, 1957, in Buffalo, New York.

[3] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[4] Numbers in parentheses refer to literature cited.

Author: Robert Youngs holds a B.S. degree from New York State College of Forestry, a ... ter of Wood Technology from University of Michigan, and a Ph.D. from Yale University. He joined the staff of the U.S. Forest Products Laboratory in 1951, where he has studied the effects of temperature and moisture content on the mechanical properties of wood and glass-fabric-reinforced plastic laminates.

Fig. 1.—Apparatus for short-time tension tests at moisture content levels below the fiber saturation point.

Fig. 2.—Apparatus for short-time compression tests at moisture content levels below the fiber saturation point.

The purpose of this work was to investigate the perpendicular-to-grain properties of wood that influence and are affected by the drying process, including tension and compression tests under short-time (static) loading as well as tests to determine the effects of duration of heating and duration of loading within the range of temperature, moisture content, and time likely to be encountered in ordinary kiln drying.

Experimental Material and Specimen Preparation

The material used for this investigation was taken from four 5-foot logs, one from each of four northern red oak trees, (*Quercus rubra* L.) from southern Wisconsin. Five planks, each 2 inches thick by 8 inches wide, were sawed from each log. Three of the planks were oriented in such a way that the growth rings were principally at 0° to the width direction. One of the others was oriented so that the growth rings were principally at 90°, and the fifth plank so that the growth rings were principally at 45° to the width direction. The mean specific gravity of the planks was 0.55, based on green volume and ovendry weight, and the moisture content of all planks was between 75 and 90 percent, values that compare closely to those listed in the Wood Handbook (25).

Wafers ½ inch long the grain were cut from the planks and assigned to tests by means of a table of random numbers. Wafers assigned to tests in other than the green condition were dried to approximately the moisture content wanted for test purposes in a small dry kiln at temperatures not exceeding 110° F. and then stored in rooms controlled at 80° F. and a relative humidity that would bring them to the desired final moisture content. Wafers assigned to tests in the green condition were stored in polyethylene bags under controlled conditions of 35° F. and 90 per cent humidity. After at least 2 months of storage under those conditions, a tension or compression test specimen was cut from each wafer. The tension specimen was 7-½ inches long, ½ inch thick (along the grain), and 1 inch wide at the ends necked down on a 4-inch radius to a ½-inch-wide net section in the central 2 inches of its length. The compression specimen was designed to correspond to the 2-inch net section of the tension specimen. After the specimens had been prepared, they were returned to the conditioning rooms in which the wafers from which they were cut had been conditioned.

Experimental Procedure

Perpendicular-to-grain static tension tests at 0°, 45°, and 90° to the growth rings and compression tests at 0° to the growth rings were carried out under each combination of the following temperature and moisture content conditions:

Temperature: 80°, 130°, and 180° F.
Moisture content: Green, 18, 12, and 6 per cent.

Two replicates from each of the four logs were tested at each angle of loading under each combination of temperature and moisture content conditions, providing a total of eight tests at each test condition. Tests were conducted in a testing chamber in which temperature and humidity could be controlled at the desired level and which was permanently mounted on a testing machine. Tension specimens were arranged as shown in Fig. 1 and loaded to failure at a constant head speed of 0.037 inch per minute. Compression specimens were arranged as shown in Fig. 2 and loaded at a constant head speed of 0.012 inch per minute to a limit of 2.5 per cent strain, since there is no real maximum load in compression perpendicular to the grain. Load was measured during test by means of a load bar mounted on static bending supports above the test chamber, the deflection of the bar under load being indicated by two SR–4, Type A–1 strain gages mounted near the midpoint. Strain of specimens was measured over a 1-inch gage length at the center of the net section by means of a pair of clip gages between the "ears" of a modified Peters averaging extensometer, as shown in Figs. 1 and 2. The sensing elements of each clip consisted of two SR–4, Type AB–3, high-temperature strain gages mounted on a phosphor bronze backing strip.

Tension and compression specimens were subjected to various periods of heating at 130° or 180° F. at 12 per cent moisture content or in the green condition in a series of tests designed to explore the effects of duration of heating. Two tension and two compression specimens from each of two logs at each combination of temperature and moisture content conditions were heated in the testing chamber for each of six heating periods uniformly spaced on a logarithmic time scale, the maximum heating period being 30 days. When each pair of specimens had been heated for the pre-assigned time, one of the pair was tested at the elevated temperature as described for static testing. The other was reconditioned under the same conditions as before heating and tested at 80° F.

Creep and recovery tests in tension and compression perpendicular to the grain were conducted at 80° and 180° F. at two levels of moisture content, 12 per cent and green. Stress relaxa-

Table 1.—RESULTS OF TESTS IN TENSION PERPENDICULAR TO GRAIN OF NORTHERN RED OAK AT THREE ANGLES TO THE GROWTH RINGS UNDER VARIOUS CONDITIONS OF TEMPERATURE AND MOISTURE CONTENT (AVERAGE BASED ON EIGHT TESTS).

Angle of loadings Degrees	Temperature °F.	Moisture content		Modulus of elasticity 1,000 p.s.i.	Proportional limit		Maximum load	
		Nominal Per cent	Actual Per cent		Strain Inches per inch	Stress P.s.i.	Strain Inches per inch	Stress P.s.i.
0	80	6	5.4	123.4	0.0054	675	0.0100	1,062
		12	11.3	112.8	.0044	499	.0152	1,018
		18	19.6	65.3	.0051	305	.0246	752
		Green	88.3	63.8	.0056	355	.0185	678
	130	6	5.5	98.7	.0043	386	.0200	1,042
		12	11.4	49.5	.0068	317	.0349	795
		18	20.6	19.4	.0119	210	.0297	437
		Green	85.0	31.5	.0033	99	.0230	297
	180	6	5.7	45.0	.0060	274	.0356	770
		12	11.9	17.1	.0065	100	.0353	336
		18	23.3	9.8	.0079	68	.0290	178
		Green	85.4	10.0	.0044	45	.0213	157
45	80	6	5.6	123.7	.0069	806	.0094	1,060
		12	11.5	111.4	.0044	437	.0159	1,058
		18	19.9	69.5	.0052	344	.0188	748
		Green	86.0	61.1	.0059	354	.0208	681
	130	6	5.9	89.5	.0065	534	.0181	974
		12	11.5	59.0	.0064	340	.0306	792
		18	19.0	34.3	.0056	141	.0346	474
		Green	83.4	35.4	.0043	121	.0239	307
	180	6	5.6	52.4	.0066	330	.0310	810
		12	12.6	21.2	.0086	130	.0484	425
		18	21.4	13.1	.0065	60	.0356	225
		Green	81.9	8.4	.0094	59	.0321	144
90	80	6	5.7	248.5	.0036	849	.0064	1,404
		12	11.6	180.8	.0052	900	.0095	1,403
		18	19.9	134.4	.0038	480	.0139	1,198
		Green	84.4	110.5	.0056	616	.0139	1,116
	130	6	5.9	171.0	.0046	763	.0092	1,308
		12	11.8	105.7	.0044	430	.0231	1,152
		18	20.1	50.6	.0075	378	.0248	796
		Green	84.9	66.8	.0042	247	.0227	586
	180	6	6.1	133.2	.0035	458	.0169	1,123
		12	13.4	31.8	.0086	225	.0393	639
		18	20.5	46.0	.0044	141	.0246	483
		Green	83.8	22.8	.0044	86	.0241	322

tion tests in tension and compression perpendicular to the grain were conducted at 75° and 180° F. at the same two levels of moisture content. One specimen from each of two logs was tested in creep and one in relaxation at each of six stress levels under each condition of temperature and moisture content, the stress levels being based on the static tensile strength under the same conditions of temperature and moisture content. Creep specimens were subjected to constant dead load for a maximum period of 3 days, or until failure occurred, strain being read at gradually increasing intervals after the load was applied. Specimens that did not fail in 3 days were unloaded and strain recovery readings were made over a similar 3-day period. Stress relaxation specimens were loaded to a preassigned level of initial stress, then held for 3 days as nearly as possible at the length attained under the initial application of load. Load readings taken at gradually increasing intervals during the test period indicated the stress-time relationship in relaxation.

Results

Static Tension and Compression Tests Results of static tests in tension perpendicular to the grain at 0°, 45°, and 90° to the growth rings at all combinations of temperature and moisture content investigated are presented in Table 1. Results of tests in compression perpendicular to the grain at 0° to the growth rings are presented in Table 2. Typical curves showing the relationship of various static properties to moisture content and temperature are presented in Figs. 3 through 7. Curves showing the relationship of modulus of elasticity in tension and compression at 0° to the growth rings to moisture content and temperature are shown in Fig. 3. Curves showing comparable relationships for tension at 90° to the growth rings are shown in Fig. 4. Curves showing the relationship of maximum stress in tension at 0° and 90° to the growth rings to moisture content and temperature are shown in Figs. 5 and 6. Curves showing the relationship of strain at failure in tension at 45° to the growth rings to moisture content and temperature are shown in Fig. 7.

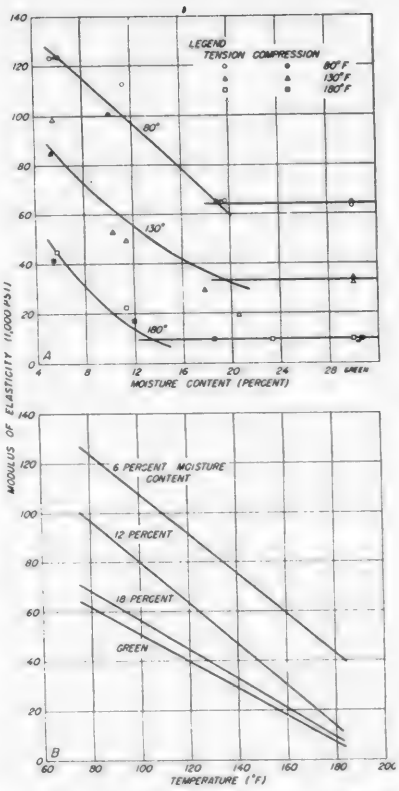


Fig. 3.—Relationship of modulus of elasticity in tension and compression perpendicular to the grain at 0° to the growth rings to (A) moisture content and (B) temperature.

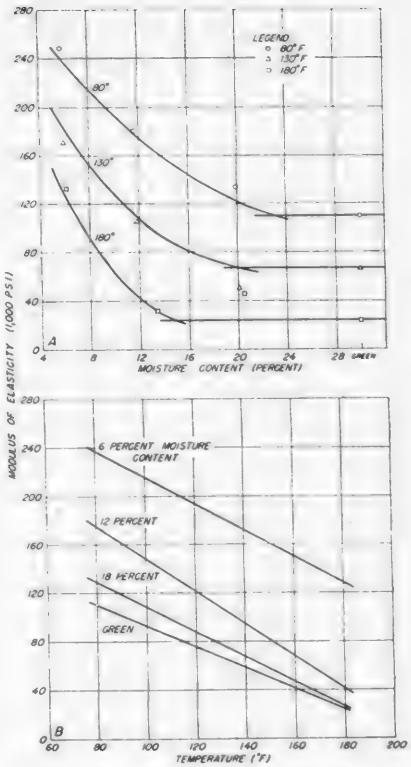


Fig. 4.—Relationship of modulus of elasticity in tension perpendicular to the grain at 90° to the growth rings to (A) moisture content and (B) temperature.

Modulus of elasticity and proportional limit stress in tension and in compression, maximum stress in tension, and stress at 2.5 per cent strain in compression were all reduced by increasing temperature between 80° and 180° F. and increasing moisture content between 6 per cent and the fiber saturation point. Statistical analyses of these data indicated that temperature and moisture content affected the various properties both independently and in combination, the effect of temperature increasing at higher levels of moisture content. For the most part, significant temperature main effects and temperature components of interactions were linear, while moisture content main effects and interaction components were predominantly curvilinear.

It was found that the data for each property at each angle of loading at moisture content levels below the fiber saturation point would be fitted rea-

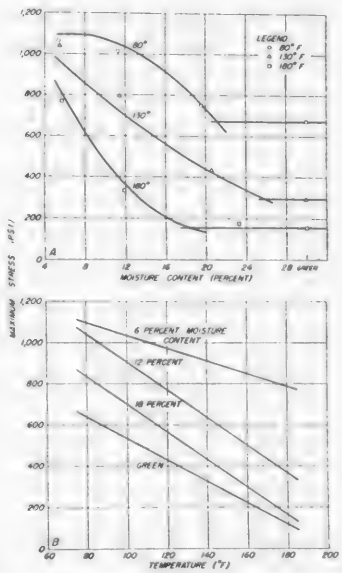


Fig. 5.—Relationship of maximum stress in tension perpendicular to the grain at 0° to the growth rings to (A) moisture content and (B) temperature.

Table 2.—RESULTS OF TESTS IN COMPRESSION PERPENDICULAR TO GRAIN OF NORTHERN RED OAK AT 0° TO THE GROWTH RINGS UNDER VARIOUS CONDITIONS OF TEMPERATURE AND MOISTURE CONTENT (AVERAGE BASED ON EIGHT TESTS).

Temperature °F.	Moisture content		Modulus of elasticity	Proportional limit		Stress at 2.5 per cent strain
	Nominal Per cent	Actual Per cent	1,000 p.s.i.	Strain Inches per inch	Stress P.s.i.	P.s.i.
80	6	5.4	123.7	0.0067	806	1,504
	12	10.1	100.8	.0058	574	1,130
	18	19.6	65.4	.0060	383	765
	Green	94.4	64.8	.0075	460	716
130	6	5.3	85.1	.0053	434	1,121
	12	10.3	52.9	.0046	263	602
	18	17.8	29.6	.0082	223	457
	Green	94.9	34.9	.0064	198	404
180	6	5.4	41.8	.0087	344	714
	12	11.3	22.3	.0051	117	286
	18	18.5	9.7	.0102	96	177
	Green	91.6	9.7	.0110	99	163

sonably well by a family of curves based on the following general equation, which assumes a quadratic relationship to moisture and a linear relationship to temperature:

$$Y = a + bT + cM + dM^2 + eTM + fTM^2 \quad (1)$$

where Y is the value of the property in question, T is temperature (°F.), M is moisture content (per cent), and a, b, c, d, e, and f are constants.

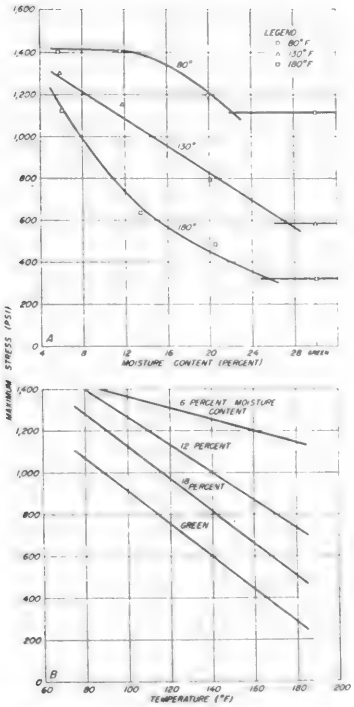


Fig. 6.—Relationship of maximum stress in tension perpendicular to the grain at 90° to the growth rings to (A) moisture content and (B) temperature.

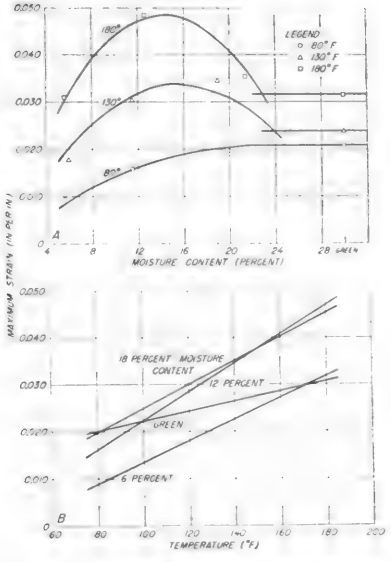


Fig. 7.—Relationship of maximum strain in tension perpendicular to the grain at 45° to the growth rings to (A) moisture content and (B) temperature.

The relationships thus developed differ in some instances from the generally assumed exponential relationship to moisture content proposed by Wilson (26). The form is similar in many respects to that observed by Sulzberger (24) for many properties of Australian species. Ellwood (5) also observed that Wilson's relationship did not hold for perpendicular-to-grain properties of beech, though Ellwood's curves differed in some respects from those of the present study.

The test results given in Table 1 show that values of tensile properties under 0° loading are quite similar to those under 45° loading, while values for 90° loading are generally higher for most properties. Strain at maximum load is the exception and appears to be nearly independent of angle of loading. The reason for this similarity of properties under 0° and 45° loading probably lies principally in the fact that deformation and final failure at these two angles of loading appear to be associated with the large rays that are characteristic of red oak. Loading at 90° to the growth rings was parallel to the large rays, so that the load was supported mainly by vessels and thick-walled fibers. Failure under 90° loading was characteristically associated with the large springwood vessels.

Modulus of elasticity under 0° loading in tension is not significantly different from that in compression. Ellwood (5) observed a similarity of modulus of elasticity of American beech in tension and compression perpendicular to the grain. Such similarity of modulus of elasticity in tension and in compression along the same orthotropic axis is generally assumed in elasticity theory and is basic to the calculation of elastic bending properties of beams, for example. Modulus of elasticity in tension is about twice as great under 90° loading as under either 0° or 45° loading at all conditions of temperature and moisture content.

It is generally considered that strain at failure in tension perpendicular to the grain will increase as either temperature or moisture content is increased. The data of Table 1 and the curves of Fig. 7 show that the effect of moisture content on this property was strongly dependent on temperature. The effects of both moisture content and temperature were generally the same at all angles of loading, but there was a tendency for the values based on tests at 90° to the growth rings to be less than those based on tests at 0° or 45°. At 80° F., the maximum strain increased nearly linearly

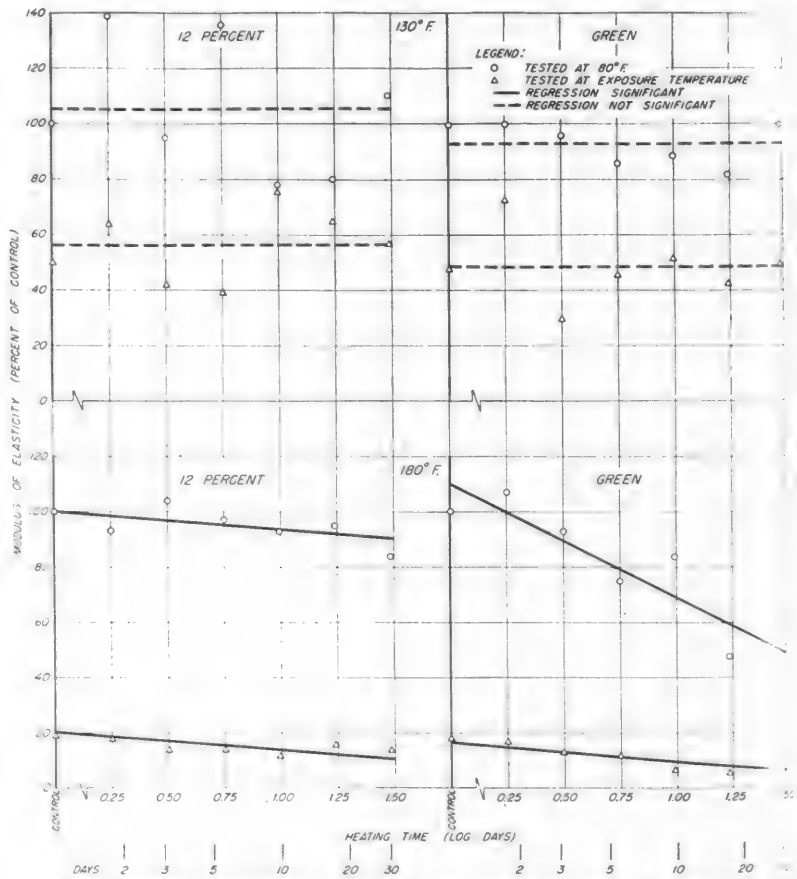


Fig. 8.—Effect of duration of heating on modulus of elasticity in tension perpendicular to the grain.

with increasing temperature, but at both 130° and 180° maximum strain appeared to reach a peak value at a moisture content of between 12 and 16 per cent and thereafter to recede to a lower value for green material. The temperature effect appears to be greatest in the 12 to 16 per cent range of moisture content and least for green material. This agrees with Kollmann's (15) observation that maximum tensile strain of green oak is nearly independent of temperature but implies that such is not the case for oak at moisture content levels below the fiber saturation point. There is nothing in the data to corroborate Greenhill's (6) observation of a peak maximum tensile strain for beech at 120° F. Rather, the data indicate a general linear increase in maximum tensile strain with increasing temperature over the entire range to 80° to 180° F. In this respect, the data are comparable to those of Ellwood (5) for beech.

Shearing Properties No tests to evaluate shearing properties directly were conducted in this investigation. It is difficult to determine accurate values of either modulus of rigidity or maximum shearing strength experimentally, since shear tests—as, for example, the block-shear test (1)—generally introduce stress concentrations that render the accuracy of the results extremely doubtful. Relationships that have been developed on the basis of the mathematical theory of elasticity as applied to orthotropic materials (20,21) make possible the calculation of values of modulus of rigidity and shearing strength that are probably more nearly descriptive of the shearing properties of the materials concerned than are values based on actual shear tests. These relationships permit shearing properties in the plane of two orthotropic axes to be calculated from the results of tension tests conducted parallel to each of these axes and in one direction intermediate to the two axes. Values of modulus of rigidity and shearing strength associated with strain in the TR plane that were calculated from tension data for the three angles of loading are presented in Table 3.

As would be expected, the trends observed in the relationship of shearing properties to moisture content and temperature are similar to those observed for the properties in tension on which they are based. The values of modulus of rigidity listed in Table 3 are generally about one-third of the modulus of elasticity in tension for 0° loading under comparable conditions of temperature and moisture content. Values of shearing strength are slightly greater than half of the comparable values of tensile strength at 0° to the growth rings.

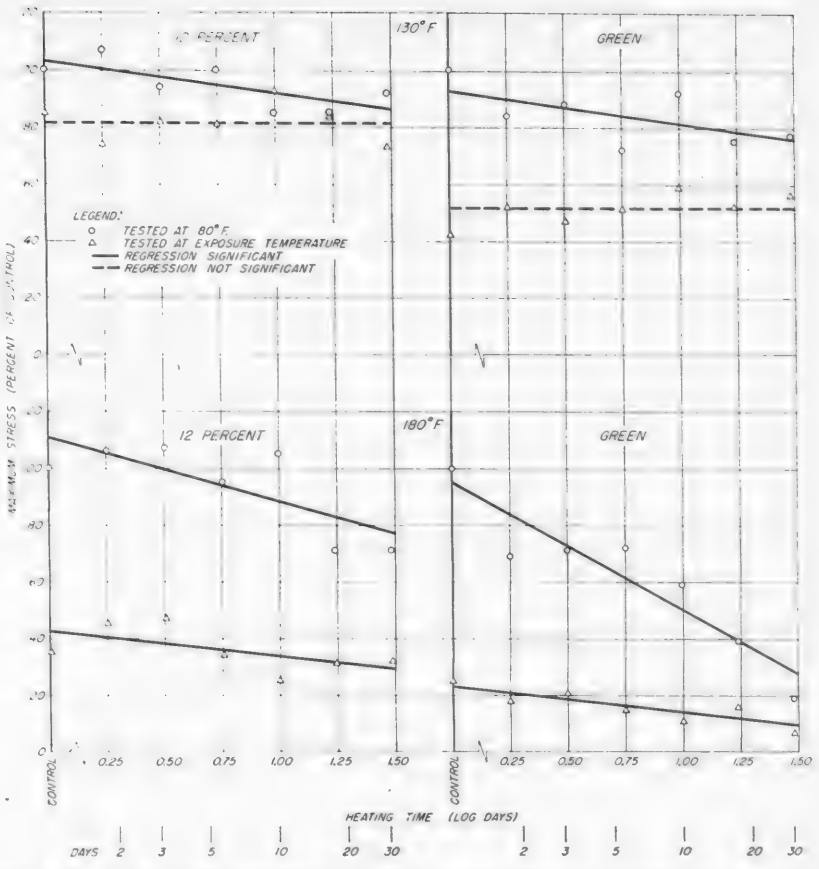


Fig. 9.—Effect of duration of heating on maximum stress in tension perpendicular to the grain.

Duration of Heating Tests

Data on modulus of elasticity and stress at maximum load in tension perpendicular to the grain for specimens exposed for various lengths of time to 130° or 180° F. at 12 per cent moisture content or in the green condition are plotted against the logarithm of heating time in Figs. 8 and 9. These are representative of the relationships observed in this study, and illustrate the effects of duration of heating on two properties of particular concern in connection with drying problems. Several analyses of variance of slopes of regression lines for various test conditions were carried out for each property in order to establish the significance of the regressions and determine which slopes, if any, could be best combined to make best use of the experimental design. Statistically significant slopes are indicated by solid lines in Figs. 8 and 9. Where no significant slope was indicated by the analysis, a horizontal dashed line is drawn at a level corresponding to the group mean.

In spite of the fact the data were generally too limited to indicate clearly more than the most pronounced effects of duration of heating, several instances of significant reduction in values of perpendicular-to-grain mechanical properties with duration of heating were noted. It was generally

Table 3.—VALUES OF MODULUS OF RIGIDITY AND MAXIMUM SHEAR STRENGTH CALCULATED ON THE BASIS OF PERPENDICULAR-TO-GRAIN TENSION TESTS AT 0°, 90°, AND 45° TO THE GROWTH RINGS.

Temperature °F.	Moisture content		Modulus of rigidity G_{TR}	Maximum shear strength F_{TR}
	Assumed Per cent	Actual Per cent	1,000 p.s.i.	P.s.i.
80	6	5.6	39.87	595
	12	11.5	37.27	598
	18	19.8	22.74	416
	Green	86.2	19.94	379
130	6	5.8	28.74	538
	12	11.6	19.90	442
	18	19.9	13.12	268
	Green	84.4	11.72	172
180	6	5.8	16.68	458
	12	12.6	7.47	263
	18	21.7	4.12	135
	Green	83.7	2.55	79

observed that, where a significant reduction in the value of a property was indicated, the relationship to the logarithm of exposure time was quite well described by a straight line, indicating an exponential relationship. Such a relationship implies, of course, that the value of a property would be reduced to zero at some finite heating time, which assumption is not justifiable on a theoretical basis. The semi-logarithmic plot makes for clearer presentation of the data in this instance, however, than would a logarithmic plot of the type employed by MacLean (15,16,17), and is not objectionable if the relationships indicated are not extrapolated beyond the 30-day limit of this investigation.

It is evident from Figs. 8 and 9 that the effects of duration of heating were much more pronounced at 180° than at 130° F. and tended to be more pronounced in green material than in material at 12 per cent moisture content. Both of these tendencies would be expected on the basis of MacLean's results, which showed an exponential relationship of strength to temperature at constant heating periods and a more pronounced effect at all temperatures when heated in water than when heated in an oven. This also agrees with Stamm's (23) conclusion that thermal degradation is greater and activation energies of degradation reactions are about half as large under steaming conditions as under dry heating conditions at the same temperature.

Maximum stress in tension perpendicular to the grain was apparently somewhat more sensitive to duration of heating effects than were the other properties investigated. The regression coefficient for this property is greater under all conditions of heating and testing than that for other tensile or compressive properties, except for a single instance of a steeper regression for tensile strain at maximum load at 130° that is of doubtful significance. This marked reduction in perpendicular-to-grain tensile strength with duration of heating is likely to influence greatly the development of drying defects, particularly in thick stock of refractory species in which the core is likely to be at a moisture content well above the fiber saturation point for relatively long periods of time under kiln-drying conditions.

The overall impression given by these data is that the perpendicular-to-grain mechanical properties of red oak are likely to be affected by heating under the conditions of temperature, moisture content, and heating time involved in normal kiln drying. The reduction in strength indicated by the present test results appears to be great enough to contribute significantly to the development of drying defects and is somewhat greater than that previously indicated for parallel-to-grain properties by the work of MacLean (15,16,17), Stamm (23), and Comben (3), though such comparisons are necessarily uncertain because of differences in tests, specimens, and test conditions. It is interesting to note, however, that work done in Australia (4) did indicate a significant effect of temperature and duration of heating on the strength and modulus of elasticity in tension perpendicular to the grain of four Australian species. The magnitude of the strength reduction indicated by the results of the present study can be fully appreciated only when it is kept in mind that the time scale of the regression lines is logarithmic. This means that 1/3 of the observed reduction took place within the first 3 days and over ½ of the observed reduction took place within the first week of heating. Fig. 9 indicates, for example, that maximum tensile strength perpendicular to the grain in a direction parallel to the growth rings was reduced from the value obtained by merely heating before testing, as in the first phase of this investigation, to about 80 per cent of this value after heating at 180° for a week at 12 per cent moisture content or for 3 days in the green condition. This fact, coupled with the reduction in effective strength due to creep under load, could have serious implications with regard to the development of drying defects.

Another conclusion to be derived from these data is that most of the reduction in strength that is caused by extended heating is permanent, not recoverable by reconditioning the wood to the same moisture content at room temperature. Furthermore, in most instances where a significant regression could be established for both the material tested at the heating temperature and that reconditioned and tested at 80° F., the ratio of the two values for any particular heating time was approximately constant at a value nearly equal to that for the control material (zero time). If substantiated by additional experimentation, this would allow strength under heating conditions to be estimated reasonably accurately from data on instantaneous effects of heating and on strength reduction indicated by reconditioned material only, such as those presented by MacLean. Such estimates would be very useful, not only with regard to drying properties, but also in the consideration of heating effects in structural members that are subjected to heating while in service.

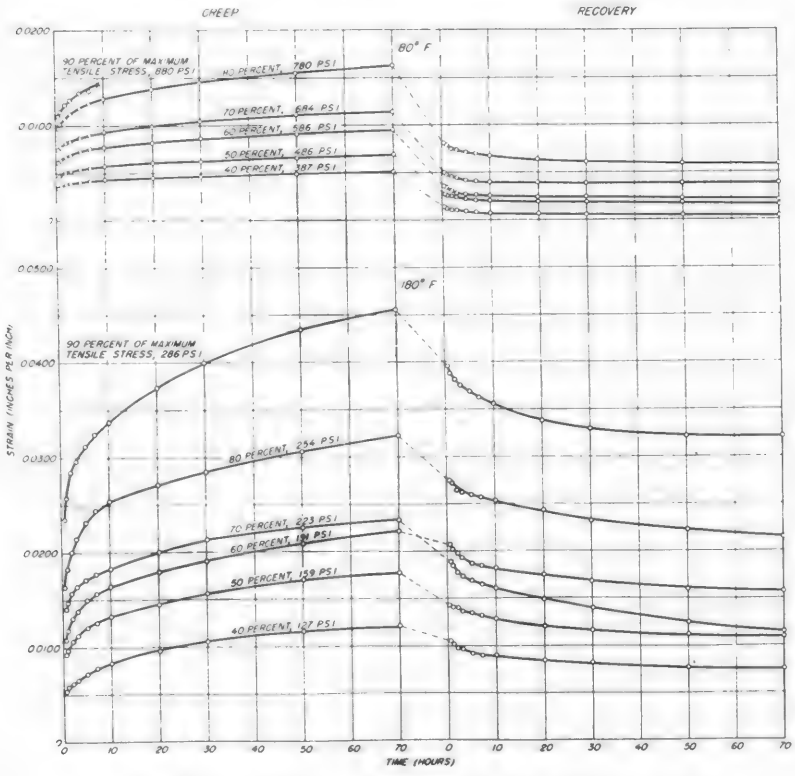


Fig. 10.—Creep and recovery from creep in tension perpendicular to the grain at 12 per cent moisture content.

Creep and Recovery Tests Curves showing the relationship of creep and recovery to time for tension perpendicular to the grain at 0° to the growth rings are presented in Figs. 10 and 11.

Compression creep and recovery results were generally similar to those based on tensile loading. When values representing creep or recovery in excess of that obtained immediately upon application or removal of load were plotted against time on logarithmic paper, the resulting curves were nearly linear. This suggested that the relationship of creep and recovery to time might be described by a function of the form.

$$e_o - e = mt^n \qquad (2)$$

where e is total strain in creep or recovery, e_o is strain taking place immediately upon application or removal of load, t is time (hours), and m and n are constants.

Since it is difficult, however, to determine the exact moment when load is fully applied to or removed from a specimen in this type of test, it is useful to consider e_o as another parameter that may be calculated from the data for any particular condition of loading. Values of the parameters n, m, and e_o were calculated for all conditions of loading for which sufficient data were available. For most groups, it was observed that n was independent of stress level at a single temperature and moisture content condition, in which instances an average n was used for calculating m and e_o for the individual stress levels.

Figs. 10 and 11 and the calculated parameters show that creep and recovery were increased by increases in both moisture content and temperature. The effect of raising the temperature from 80° to 180° F. at the same moisture content was considerably greater than that of raising moisture content from 12 per cent to the green condition at the same temperature. The combined effect of high temperature and high moisture content, moreover, was much greater than that of the individual temperature and moisture content effects added together, particularly in the tension creep tests, indicating a strong interaction of temperature and moisture content at 180° F. in the green condition. A similar interaction was observed in creep studies conducted in Australia by Grossman and Kingston (10).

The parameters e_o and m for creep in tension and compression are generally characterized by a greater than linear increase with increasing stress level within each group. The comparable parameters for recovery, however, are characterized by a generally linear increase with increasing stress. The parameter, n, in contrast to the other two parameters, does not appear to be related to stress, except for the compression creep tests at 80°. In that instance, closer investigation of the conditions disclosed the possibility of external restraint in the compression jig that may have appreciably affected the results.

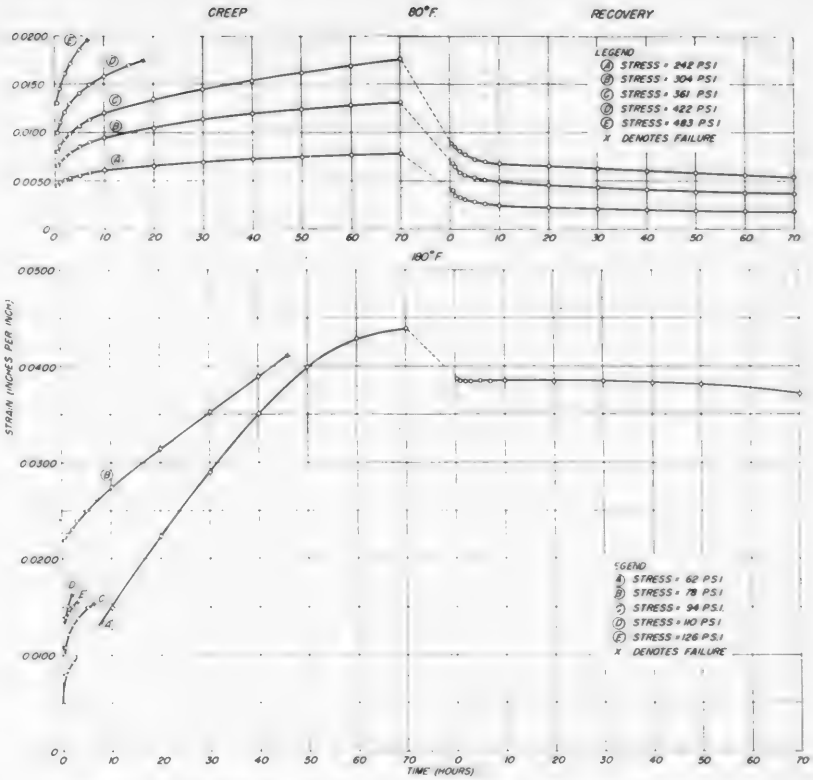


Fig. 11.—Creep and recovery from creep in tension perpendicular to the grain in the green condition.

Earlier work done at the U. S. Forest Products Laboratory also indicated an apparent independence of n on stress for creep of wood in tension and compression. If it is assumed that n is generally independent of stress, as seems reasonable on the basis of present results, it then follows from consideration of equation (2) and the observed characteristics of the other parameters that, at any time, t, for any given temperature and moisture content condition within the range covered by this investigation, the amount of creep must increase more than proportionately with stress and the amount of recovery must be nearly proportional to the stress from which the material is recovering.

While n appears to be generally independent of stress, it is not independent of either temperature or moisture content. The values of n for green material are about 1½ to 1¾ times those for material at a nominal 12 per cent moisture content and the values of n for material at 180° F. are about 1¼ to 1½ times those for material at 80° F. at the same nominal moisture content. The actual moisture content of the 12 per cent material at 180° F. was appreciably lower than that of the comparable material at 80°, however, so the difference between values of n for the two groups is undoubtedly less than would be observed at the same level of moisture content.

These concepts relative to the effect of temperature, moisture content, and stress on the perpendicular-to-grain creep characteristics of red oak will undoubtedly shed light on the answers to many drying problems. It would be particularly useful, however, to be able to distinguish between recoverable and irrecoverable creep, since the irrecoverable creep, or set, is instrumental in the development of drying stresses. It seems likely that a reasonably accurate separation of the irrecoverable from the recoverable creep can be made by application of Boltzmann's superposition principle (14), which states that the deformation at any instant of a body manifesting recoverable creep is due not only to the load acting at that instant, but to the entire previous loading history of the body. In this regard, the removal of load would correspond to application of negative load equal in magnitude to the load removed. Grossman and Kingston indicated (10) that this principle could be applied to wood for relatively long loading times and that (11) the irrecoverable creep function can be found from the difference between a creep curve and recovery curve after a long loading time. This concept was also expressed by Leaderman (14) and by

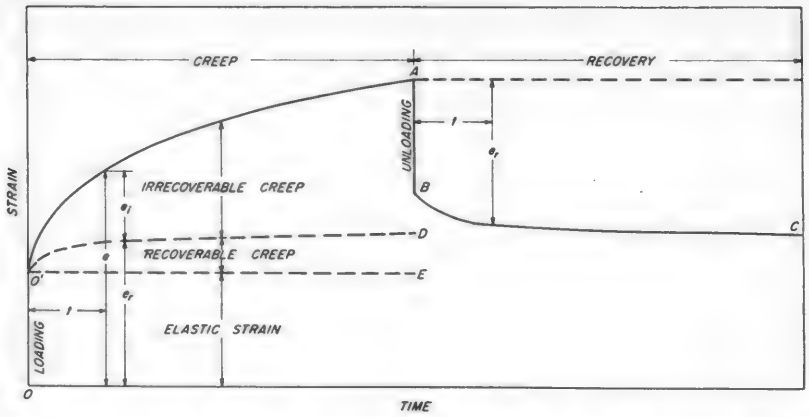


Fig. 13.—Relationship between irrecoverable creep and stress in tension perpendicular to the grain at 12 per cent moisture content.

Pao and Marin (22) for other materials, and appears to be valid for cases where recoverable creep has essentially reached completion. While it is obvious from the curves of Figs. 10 and 11 that total creep had not reached completion at the time of unloading, many of the recovery curves do approach a horizontal asymptote rather closely at the end of an equal recovery time, indicating that recoverable creep had probably approached essential completion at the time of unloading.

Irrecoverable creep could then be estimated by superposition of a recovery curve on the preceding creep curve, as shown in Fig. 12. Values of irrecoverable creep were thus determined from the tensile creep and recovery curves for the material at 12 per cent moisture content tested at 80° and 180° F. and are shown in relation to stress in Fig. 13. These curves indicate that irrecoverable creep increases several times as rapidly at 180° as at 80° F. at the same moisture content and that irrecoverable creep proceeds rapidly for the first few hours of loading, the rate gradually diminishing with increasing time. The curves also point out the fact that irrecoverable creep increases more than proportionately with stress, leading to the conclusion that a considerable part of the nonproportionality of the creep curves must be due to irrecoverable creep. Grossman and Kingston (8, 9) arrived at a similar conclusion on the basis of creep tests in tension, compression, and bending.

Stress Relaxation Tests The observed stress at constant strain as a function of time is shown in Fig. 14 for tests conducted at 75° F. and in Fig. 15 for tests conducted at 180° F. As was characteristic of creep test results, there are many gaps in the data as well as erratic data caused largely by failure or erratic behavior of the strain-measuring equipment under the severe conditions of test. It is possible, however, to distinguish certain trends that give valuable clues to the rheological behavior of the material investigated.

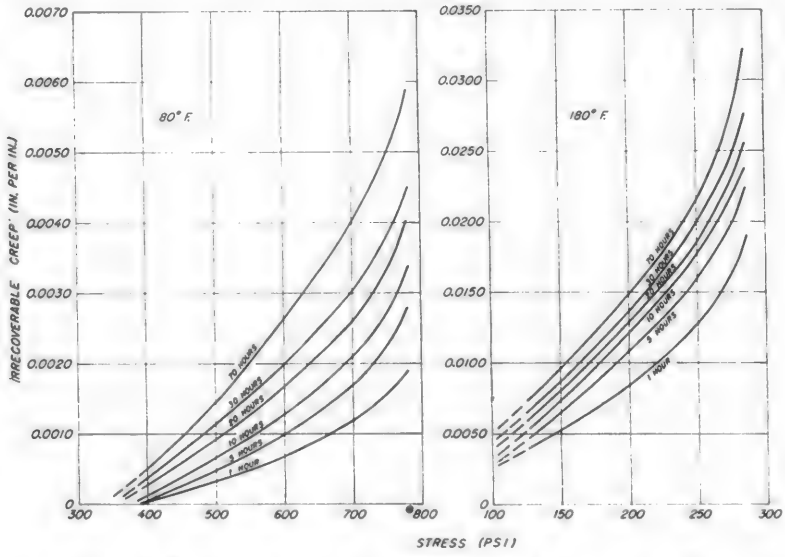


Fig. 12.—Method of estimating rate of development of irrecoverable creep by superposition of recovery curve on creep curve.

By selecting a suitable time scale, it was observed that the data of the present investigation could be fitted by the expression,

$$f = f_o\ (t+1)^b \qquad (3)$$

where f is stress at time, t, f_o is initial stress, t is relaxation time (minutes), and b is a constant indicating the slope of the straight line on a logarithmic plot. Equation (3) has a theoretical advantage over the commonly applied Kitazawa relationship (12) in that it goes to f_o at zero time and approaches zero stress asymptotically with increasing time. In addition, it has the advantage that it is of the same general form as equation (2), which describes the creep and recovery behavior. Despite the fact that the relationship between creep and stress relaxation is extremely complex in a material such as wood, it seems likely that subsequent analyses based on the findings of this and similar investigations will be facilitated by having expressions of the same basic form for the two aspects of rheological behavior.

To fit equation (3) to the data of the present investigation, stress values obtained by test were plotted against time in minutes plus 1 minute on a logarithmic plot. Values of b were then calculated as slopes of the straight lines fitted to these logarithmic plots. In order to provide relaxation data comparable to those of previous studies of stress relaxation in wood, values of the relaxation coefficient, m, were calculated on the basis of Kitazawa's equation (12).

The curves of Fig. 14 and 15 show that perpendicular-to-grain stress relaxation follows the same general relationship to time that has been observed previously for wood by Kitazawa (12) and by Grossman (7) and for textile fibers by Leaderman (14).

The calculated values of b and m indicate that relaxation takes place much more rapidly at 180° than at 75° F. at the same level of moisture content in both tension and compression. These values do not, however, indicate the marked interaction between temperature and moisture content that was characteristic of creep test results. Values of both b and m for tests at 75° F., from which the most reliable and consistent results were obtained, show a marked tendency to increase with increasing stress, through a similar trend is not apparent in the more erratic data for tests at 180° F. Kitazawa (12) observed that the relaxation coefficient did not vary with stress below about one-fourth to one-third of the proportional limit stress, indicating that the upper limit of initial stress for normal relaxation is in that range. Presumably, this normal relaxation is a manifestation of

recoverable creep only and does not involve irrecoverable creep. In view of the fact that all stress levels in the present investigation were well above the limit observed by Kitazawa, it is likely that the observed increase in b and m with increasing stress is due to the large stress-related amounts of irrecoverable creep.

Application of the Results

The results of this investigation provided considerable fundamental information on the perpendicular-to-grain strength, elastic, and rheological properties of northern red oak under normal kiln-drying conditions. The first, and most direct, application of the information will be in gaining a better understanding of the drying behavior of the particular species involved. A major part of that work will consist in correlating the results with information on drying stresses and set gathered by McMillen (18, 19) on material matched to that used in the present investigation. The results of this investigation should also be applicable, at least in a general way, to a better understanding of the drying behavior of other refractory hardwoods. It is planned to conduct similar investigations on at least one softwood and at least one nonrefractory hardwood, since both the drying behavior and the mechanical properties of these broad groups are known to differ in some of their fundamental aspects from the behavior and properties of northern red oak.

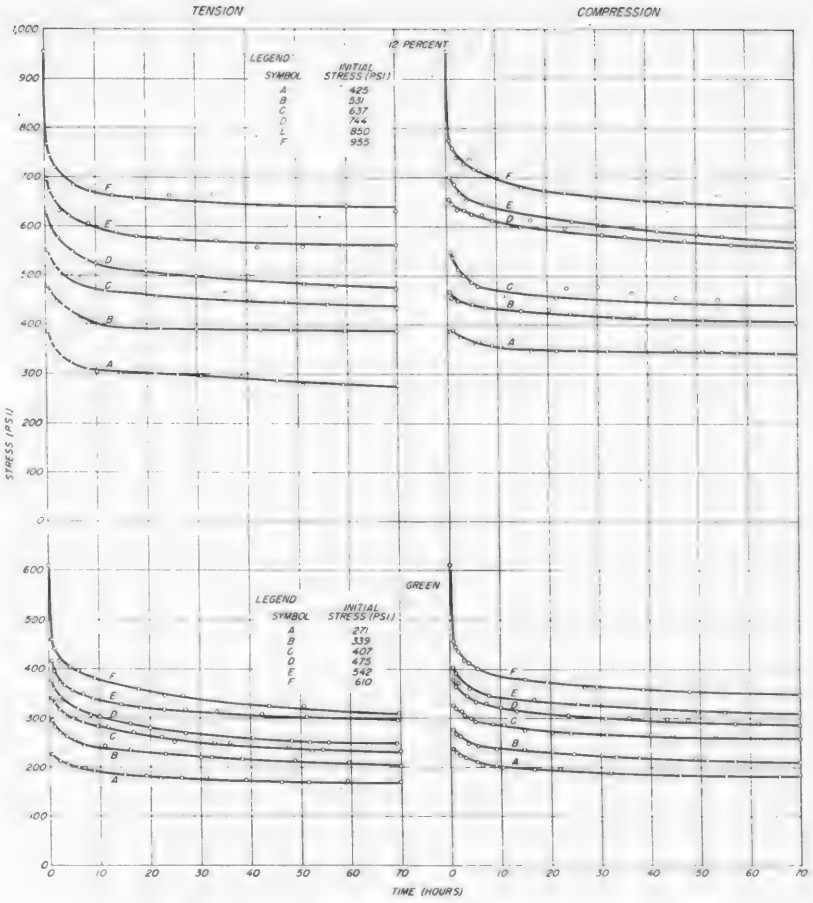


Fig. 15.—Stress relaxation in tension and compression perpendicular to the grain at 180° F.

It is also possible that the results of this work may find some application to problems involving the effects of temperature, moisture content, and duration of heating and loading on structural members. One outstanding example would be certain structural elements of cooling towers that are subjected to continuous heating by hot water while they are under load and have been observed to fail at stresses well below the usual design stresses after relatively short periods of service.

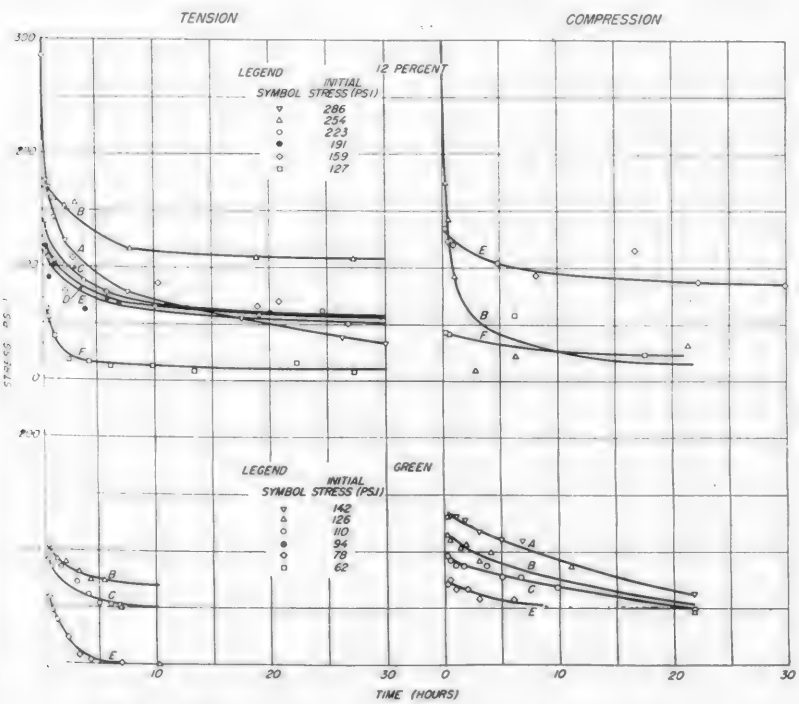


Fig. 14.—Stress relaxation in tension and compression perpendicular to the grain at 75° F.

Conclusions

On the basis of the results of this investigation, the following conclusions may be drawn relative to the perpendicular-to-grain mechanical properties of northern red oak.

Most static properties are reduced linearly by increasing temperature between 80° and 180° F. and curvilinearly by increasing moisture content between 6 per cent and the fiber saturation point.

Tensile properties at 0° to the growth rings are quite similar to those at 45° to the growth rings, while those at 90° are markedly greater under the same conditions of temperature and moisture content.

Strain at maximum load in tension is an exception to the general rule in

that it does not appear to be dependent on angle to the growth rings and increases with increasing temperature, the temperature effect being most pronounced at intermediate moisture levels and very slight in the green condition.

Modulus of elasticity under loading at 0° to the growth rings in tension is not significantly different from that in compression.

Static properties can be permanently reduced by heating under conditions likely to be encountered in kiln drying. Maximum tensile stress appears to be more sensitive to such effects than are the other properties investigated.

Creep and stress relaxation are increased by increasing temperature, moisture content, or initial stress. A large part of the increase is apparently due to irrecoverable creep.

The present investigation was so broad in scope that much of it was necessarily little more than exploratory in nature. Each phase of this work could profitably be the subject of intensive investigation. The results of this research, particularly after they have been correlated with results of drying stress studies, should indicate the particular points to be emphasized in order to make the results of such future work most valuable and applicable to a fundamental understanding of drying behavior.

Literature Cited

1. American Society for Testing Materials. 1954. A.S.T.M. standards on wood, wood preservatives, and related materials. A.S.T.M., Philadelphia.
2. Barnard-Brown, E. H., and R. S. T. Kingston, 1951. Effect of temperature and grain orientation on strength properties of wood in tension perpendicular to the grain. (Australia) C.S.I.R.O. Div. For. Prod. Proj. T.P. 10–3.
3. Comben, A. J. 1955. The effect of high temperature kiln drying on the strength properties of timber. Wood (Eng.) 20:8:311–313.
4. Commonwealth Scientific and Industrial Research Organization (Australia) 1955. Annual Report, Div. For. Prod., 1954–1955.
5. Ellwood, E. L. 1954. Properties of American beech in tension and compression perpendicular to the grain and their relation to drying. Yale Univ. School of Forestry Bull. No. 61.
6. Greenhill, W. L. 1936. Strength tests perpendicular to the grain of timber at various temperatures and moisture contents. Jour. Council for Sci. and Indus. Res. (Australia) 9:4:265–278.
7. Grossman, P. U. A. 1954. Stress relaxation in wood. Nature (Lond.) 173: 4392:42–43.
8. ————, and R. S. T. Kingston. 1954. Creep in tension and compression. The influence of stress on creep. (Australia) C.S.I.R.O. Div. For. Prod. Proj. 16–2, Prog. Rept. No. 1.
9. ————. 1954. Creep and stress relaxation in wood during bending. Australia Jour. Appl. Sci. 5:4:403–417.
10. ————. 1955. Superposition tests. (Australia) C.S.I.R.O. Div. For. Prod. Proj. T.P. 16–4, Prog. Rept. No. 1.
11. ————. 1955. Mechanical conditioning of high polymers. Australian Jour. Appl. Sci. 6:4:442–452.
12. Kitazawa, G. 1947. Relaxation of wood under constant strain (A study of the visco-elastic property of wood). New York State College of Forestry Tech. Publ. No. 67.
13. Kollmann, F. 1950. Untersuchungen über die ursachen von schäden bei der trocknung von grünem eichenholz zugleich mitteilug über festigkeits-prufungen an holz in hochfrequenten wechselfeld. Svenska Träforskningsinstitutet, Trätekniska Avdelningen, Meddelande 21. (Translated from the German by Hildegarde Kipp)
14. Leaderman, H. 1944. Elastic and creep properties of filamentous materials and other high polymers. Textile Foundation, Washington, D.C.
15. MacLean, J. D. 1953. Effect of steaming on the strength of wood. Amer. Wood-Pres. Assn. Proc. 49:88–112.
16. ————. 1954. Effect of heating in water on the strength properties of wood. Amer. Wood-Pres. Assn. Proc. 50:253–280.
17. ————. 1955. Effect of oven heating and hot pressing on strength properties of wood. Amer. Wood-Pres. Assn. Proc. 51:227–249.
18. McMillen, J. M. 1955. Drying stresses in red oak. For. Prod. Jour. 5:1:71–76.
19. ————. 1955. Drying stresses in red oak: Effect of temperature. For. Prod. Jour. 5:4:230–241.
20. Norris, C. B. 1955. Strength of orthotropic materials subjected to combined stresses. U.S. Forest Products Laboratory Report No. 1816.
21. ———— and P. F. McKinnon. 1946. Compression, tension, and shear tests on yellow-poplar plywood panels of sizes that do not buckle with tests made at various angles to the face grain. U.S. Forest Products Laboratory Report No. 1328. (Information reviewed and reaffirmed Feb. 1956)
22. Pao, Y. H., and J. Marin. 1953. An analytical theory of the creep deformation of materials. Jour. Appl. Mechanic 20:2:245–252.
23. Stamm, A. J. 1956. Thermal degradation of wood and cellulose. Ind. Engrg. Chem. 48:3:413–417.
24. Sulzberger, P. H. 1953. The effect of temperature on the strength of wood, plywood, and glued joints. (Australia) Aero. Res. Consultative Committee Report ACA–46.
25. U.S. Forest Products Laboratory. 1955. Wood handbook. U.S. Dept. Agr. Handbook No. 72.
26. Wilson, T. R. C. 1932. Strength—moisture relations for wood. U.S. Dept. Agr. Tech. Bull. 282.

Creep and Other Strain Behavior of Wood in Tension Parallel to the Grain[1,2]

EDWARD G. KING, Jr.

Yale School of Forestry

The experimental relationship between creep and stress level indicates that creep occurs at stress levels below 10 per cent of ultimate tensile strength. Results suggest the relation of creep to stress level would be most accurately described by a two-stage relationship consisting of a linear regression up to the threshold of set and a curvilinear regression thereafter. Both creep and static test results indicate that wood does not behave according to Hooke's Law in tension parallel to the grain.

Introduction

THE REPORT PRESENTS THE FIRST RESULTS obtained in an investigation of the short-term creep behavior of wood in tension parallel to the grain.

The objectives of the investigation are to determine the general relationship between creep and stress level for representative domestic and tropical species, and to test the applicability of conventional elastic theory to wood stressed in tension parallel to the grain. Although the investigation is of a basic nature, the results should be helpful to those more applied studies concerned with wood under stress, such as accelerated seasoning, steam bending, and long-term loading.

Previous Investigations

It has long been known that wood deforms or elongates under a sustained load. This property, called creep, and its companion property, long-term

[1] 1957 Wood Award Entry.

[2] This research is part of a comprehensive study being conducted at the Yale School of Forestry in cooperation with the Office of Naval Research, Department of the Navy, under Contract Nonr 609(13), Project NR 31–001, Properties of Tropical Woods.

The Author: Edward King holds B.S. and M.S. degrees in Forestry from Purdue University. From 1952 to 1954 he was a research assistant in wood mechanics research in the Purdue Department of Forestry. He currently is studying for the Doctor of Forestry degree at the Yale School of Forestry.

strength, have been subjects of investigation since 1880, at least. The earlier studies (8, 10, 12, 16, 17)[3] were concerned largely with the behavior of wood under sustained compressive and bending loads. Little information was available concerning the creep behavior of wood in tension paralled to the grain until about 1940.

Minami (14), investigating the creep behavior of Sitka spruce and *Chamaecyparis obtusa* in tension parallel to the grain, observed creep at stresses ranging from 15 to 20 per cent of the ultimate strength. He found that the creep-time relationship could be approximated by an exponential function, and that the creep rate-stress level relationship could be described by a power function. Minami reports that permanent set began at about the 50 per cent stress level. He also found that stresses of approximately 70 per cent of the short-term strength could be sustained for as long as 500 hours.

The Australian Forest Products Laboratory (1) reported observing creep in tension at stresses less than 10 per cent of the ultimate strength.

Grossman and Kingston (3), working with hoop pine, found no correlation between initial elongation and tensile stress, but did find that creep increased more than linearly with increasing stress, the greater part of this increase being due to irrecoverable strain.

Dietz (2) found from creep tests on Douglas-fir that the creep rates in direct tension are very low, but in general, are more marked than in compression.

Wood (18) reported that tests at the U. S. Forest Products Laboratory have shown that there is noticeable creep in tension and compression of Douglas-fir and white oak at stresses as low as 1500 psi. Wood also reported that there is an indication that creep in tension and compression is approximately proportional to stress.

The high polymers in the form of textile fibers have been extensively studied, and much information is available concerning their mechanical behavior. The creep-recovery-time and the repeated stress-strain relationships exhibited by wood, whose basic component is the cellulose molecule, are strikingly similar to the behavior of these organic fibrous substances (4,9). The high polmers characteristically fail to exhibit proportional stress-strain relations, nor do they behave elastically (9, 11).

Ivanov (6, 7) has maintained that wood, like the high polymers, exhibits non-proportional stress-strain relationships. On the basis of a large number of tests in which it was found that the load-deformation curves were curvilinear from the beginning of loading, Ivanov concluded that there is no elastic limit in wood, and that the proportional limit is a fictitious value. He has reported that, for a constant rate of loading, the variation of total deformation with stress below a certain limit, which he calls the lower limit of plastic flow, is expressed by the equation

$$y = a_1\sigma + a_2\sigma^2$$

where y = total deformation, a_1 = elastic deformation constant, a_2 = residual deformation constant, and σ = stress.

According to Ivanov, the limit of plastic flow corresponds to the safe long-term strength.

[3] Numbers in parentheses refer to literature cited.

Test Procedure

The creep behavior of basswood, cedro branco (*Cedrela huberi*), and angelique (*Dicorynia paraensis*) are discussed in this report. Creep values were determined for a 30-minute sustained-load period for stress levels ranging from 5 to 85 per cent of ultimate tensile strength. Each species was represented by specimens from three boards, the specimens from a particular board being designated as a test series. Where possible, these boards were taken from different logs.

The type B tension specimen described in A. S. T. M. D805–52 was used. This specimen is 16 in. long, 1 in. by ¼ in. at the grips, and tapers down to ½ in. by ¼ in. at the critical section. Specimens were conditioned and stored over a saturated sodium nitrite solution at laboratory temperatures. The relative vapor pressure above this salt solution provided a nominal moisture content of 12 per cent.

Strains were measured with SR–4, A–5 paper-mounted electrical resistance strain gages. Gages, all of the same lot number and with the same gage factor, were attached to the specimens of each series with Duco cement. After a gage curing period of at least 48 hours, three coats of Angier resin were applied to each specimen to prevent moisture loss during test. The area immediately surrounding the gage was left uncoated. Leads of single strand, plastic-coated No. 20 wire were soldered to each gage. The gage and the uncoated area around the gage were covered with a silicone grease, and the entire critical section was wrapped with a polyvinyl plastic film.

The specimens in each series were tested in two groups. The specimens in one group served as compensating gages for specimens in the other group being tested. Approximate stress levels were determined for each series from matched control specimens tested to failure at a machine speed of 0.035 in. per minute. All tests were conducted at laboratory temperatures.

Sustained-load tests were of 30 minutes duration. A loading time of one minute was used for all tests. Specimens were held in Templin self-aligning and self-tightening grips, and loads were applied with a Baldwin–Southwark hydraulic testing mechine. Strains were measured to the nearest microinch (± 1½ microinches) with a Baldwin Type K strain analyzer. A 14-minute gage warm-up period was provided before loading was begun. During test, the specimen with the compensating gage was held firmly in a special jig designed for this purpose.

Strain-gage creep was assumed to be negligible during the 30-minute sustained-load period. This assumption was based on information supplied by the gage manufacturer.

Several days before test, the stability of the zero (or unloaded) strain reading of each pair of specimens (the current active test specimen and the specimen providing the compensation gage) was determined. This was done by placing the specimens in the holding jig and measuring the drift over a 30-minute period after allowing a 15-minute warm-up period. This measurement, designated as the drift correction factor, was used to adjust the experimental creep values for zero drift.

It was found that observed drift was independent of the method by which the specimens were held, and was not a result of small temperature or moisture-content changes. Repeated determinations showed that the magnitude and direction of this drift were constant for a given pair of specimens. Drift corrections averaged about six microinches. Gages on those specimens that showed drift greater than 15 microinches were replaced.

To determine the approximate threshold of permanent set, a number of specimens were tested at successively higher stress levels until significant set, as shown by the change in the unloaded strain reading, occurred. As an alternative method, a number of specimens were tested repeatedly at their same respective stress levels, and it was assumed that set had occurred when a significant trend existed between creep and cycle number. Specimens tested by either of these procedures were given at least a two-day recovery period between loading cycles.

After the completion of all sustained-load tests, each specimen was tested to failure at a machine speed of 0.035 in. per minute. Stress levels were expressed as a percentage of the average ultimate strength for the series, except as noted otherwise. Strain at

Table 1.—STATIC AND CREEP TEST DATA FOR CEDRO BRANCO IN TENSION PARALLEL TO THE GRAIN

Series* and specimen	Specific gravity (O.D. Vol.)	Static test: Ultimate tensile strength	Static test: Maximum strain	Creep test: Stress level†	Creep test: Creep 2–30 min.	Creep test: Drift correction 2–30 min.	Creep test: Corrected creep 2–30 min.	Creep test: Initial strain plus creep 0–2 min.	Creep test: Temperature during creep test
		p.s.i.	microinches per inch	%		microinches per inch			°F
A1	0.45	14,230	9,600	10.2	9	— 3	6	920	79
A2	0.45	14,550	9,550	20.3	17	+10	27	1,800	80
A3	0.47	13,080	8,370	30.5	44	— 2	42	2,840	79
A4	0.46	15,380	9,570	40.6	49	— 2	47	3,550	79
A5	0.47	14,730	9,100	50.8	73	+ 2	75	4,540	82
A6	0.45	13,260	8,320	60.9	86	+ 2	88	5,450	76
A7	0.45	15,550	9,820	74.9	161	—10	151	6,940	75
A8	0.45	16,300	10,060	76.1	193	+ 2	195	6,840	81
A9	0.44	13,540	9,080	81.2	233	— 2	231	8,100	77
Av.		14,510							
B1	0.44	13,970	9,410	9.9	7	+ 1	8	1,090	[illegible]
B2	0.46	17,190	10,500	20.2	9	+ 7	16	1,950	82
B3	0.46	15,560	9,350	29.5	30	— 2	28	2,790	[illegible]
B4	0.48	16,960	9,620	41.4	54	+ 3	57	3,670	8[illegible]
B5	0.43	17,370	11,600	50.0	86	— 1	85	5,080	[illegible]
B6	0.44	17,300	11,820	59.1	107	+ 2	109	6,260	7[illegible]
B7	0.49	17,020	9,760	70.3	144	— 3	141	6,530	81
Av.		16,480							
C1	0.46	17,220	10,820	10.2	5	+ 5	10	1,080	8[illegible]
C2	0.46	17,040	10,760	20.0	17	+ 6	23	2,020	[illegible]
C3	0.45	16,870	11,100	30.2	41	— 2	39	3,200	[illegible]
C4	0.47	16,800	10,520	40.3	50	— 6	44	4,120	[illegible]
C5	0.46	18,130	11,220	50.2	79	+ 2	81	5,120	[illegible]
C6	0.45	17,540	11,080	61.0	88	+ 2	90	6,340	[illegible]
C7	0.44	16,840	9,900	70.8	129	— 6	123	7,500	[illegible]
C8	0.46	16,520	10,470	75.8	185	— 2	183	7,910	[illegible]
C9	0.44	15,950	10,800	79.2	250	— 5	245	9,140	[illegible]
C10	0.46	16,870	9,810	86.0	200	+ 6	206	8,480	[illegible]
Av.		16,980							

*Moisture content: Series A—14.2 per cent, Series B—15.1 per cent, Series C—15.0 per cent.
†Stress level expressed as a percentage of the average ultimate strength of each series.

failure was not adjusted for previous set. No corrections were made for transverse sensitivity of the gages (5, 15), nor were the gages preloaded before test.

The moisture contents for each series were determined from control specimens.

All cedro specimens had a slope of grain less than 1 in 26. Of the 17 basswood specimens, six had slopes of grain ranging from 1 in 18 to 1 in 24, and 11 had slopes of grain less than 1 in 26.

Angelique possesses natural interlocked grain. The average slope of grain of the material from which the test specimens of this species were selected was 1 in 22.

Results and Analysis

The ultimate strength, maximum strain, sustained stress (in per cent), creep value, drift correction, approximate initial strain, and test temperature of each cedro, basswood, and angelique specimen are given in Tables 1, 2, and 3, respectively.

Each creep value in these tables is that associated with the sustained load occurring between the second and thirtieth minute of the sustained-load period. At the higher stress levels, difficulty was encountered in maintaining a stable load during the first two minutes of test. This was due to the rapid rate at which the load had been applied and to crushing of the specimen in the grips. The sensitivity of the gages was such that even small fluctuations in load caused significant fluctuations in strain measurements. The 28-minute period, rather than the full 30-minute sustained-load period, was chosen as the creep time interval in order to obtain more accurate creep values.

Table 2.—STATIC AND CREEP TEST VALUES FOR BASSWOOD IN TENSION PARALLEL TO THE GRAIN

Series* and specimen	Specific gravity (O.D. Vol.)	Static test: Ultimate tensile strength	Static test: Maximum strain	Creep test: Stress level†	Creep test: Creep 2–30 min.	Creep test: Drift correction 2–30 min.	Creep test: Corrected creep 2–30 min.	Creep test: Initial strain plus creep 0–2 min.	Creep test: Temperature during creep test
		p.s.i.	microinches per inch	%		microinches per inch			°F
A1	0.39	12,730		5.8	6	— 2	4	520	[illegible]
A2	0.39	11,270		7.4	13	+ 1	14	730	[illegible]
A3	0.38	10,360		9.9	23	— 7	16	800	[illegible]
A4	0.39	8,540		13.2	29	— 8	21	1,060	[illegible]
A5	0.39	8,540		18.2	27	+ 7	34	1,280	[illegible]
A6	0.39	14,180		26.4	48	— 1	47	1,940	[illegible]
A7	0.39	11,460		33.8	85	+ 2	87	2,480	[illegible]
Av.		11,010							
B1	0.41	16,360	11,720	14.6	29	— 4	25	1,520	[illegible]
B2	0.41	14,180	10,350	34.1	93	— 8	85	3,390	[illegible]
B3	0.41	14,130	10,000	44.2	117	+ 3	120	5,470	[illegible]
B4	0.41	15,050	11,500	54.1	230	+ 6	236	5,750	[illegible]
B5	0.41		cycle 1	19.5	32			2,020	[illegible]
B5			cycle 2	69.4	496			7,890	[illegible]
B6	0.42		cycle 1	29.5	79			3,350	[illegible]
B6			cycle 2	86.0	704			10,630	[illegible]
Av.		14,930							
C1	0.40	11,530		8.6	1	— 2	—1	950	[illegible]
C2	0.39	10,180		14.7	24	— 4	20	930	[illegible]
C3	0.39	10,180		35.4	48	+ 5	53	2,390	[illegible]
C4	0.40	10,160		47.1	92	+ 4	96	3,500	[illegible]
Av.		10,520							

*Moisture content: Series A—11.4 per cent, Series B—11.4 per cent, Series C—11.1 per cent.
†Stress level expressed as a percentage of the average ultimate strength of each series.

Table 3.—STATIC AND CREEP TEST DATA FOR ANGELIQUE IN TENSION PARALLEL TO THE GRAIN

Series* and specimen	Specific gravity (O.D. Vol.)	Static test: Ultimate tensile strength	Static test: Maximum strain	Static test: Stress level†	Creep test: Creep 2–30 min.	Creep test: Drift correction 2–30 min.	Creep test: Corrected creep 2–30 min.	Creep test: Initial strain plus creep 0–2 min.	Creep test: Temperature during creep test
		p.s.i.	microinches per inch	%	microinches per inch				°F
A1	0.78	24,600	9,950	10.4	—1	+ 6	5	910	82
A2	0.77	23,650	8,840	20.4	16	— 6	10	1,880	85
A3	0.77	26,840	9,470	30.8	16	+ 3	19	2,620	80
A4	0.78	28,050	11,140	41.5	40	+ 1	41	3,900	81
A5	0.78	26,200	9,120	51.8	38	+ 5	43	4,480	80
A6	0.77	23,420	9,690	62.3	115	— 6	109	5,410	82
A7	0.78	25,000	8,890	63.5	79	+ 1	80	5,640	84
A8	0.78	26,370	9,230	72.6	62	— 2	60	6,530	81
A9	0.78	25,130	8,280	82.2	168	— 2	166	6,930	86
A10	0.77	26,790	9,660	83.0	166	— 1	165	7,490	81
Av.		25,610							
B1	0.77	26,320	8,190	9.3	4	— 5	—1	740	83
B2	0.79	25,180	8,510	18.5	—2	+ 6	4	1,530	79
B3	0.79	26,640	8,730	28.0	21	— 3	18	2,360	82
B4	0.79	25,220	8,190	36.7	23	+10	33	3,130	82
B5	0.78	24,820	8,290	46.9	32	— 4	28	3,910	83
B6	0.78	27,790	9,340	47.3	61	+ 2	63	4,170	83
B7	0.77	27,080	9,830	55.3	51	+ 5	56	4,920	81
B8	0.79	26,160	8,380	65.2	92	+ 4	96	5,520	80
B9	0.78	29,740	9,580	73.4	95	— 4	91	6,040	82
B10	0.78	------	------	77.3	138	0	138	6,740	78
Av.		26,550							
C1	0.73	11,250	8,180	11.1	14	+ 3	17	880	80
C2	0.73	15,840	12,410	15.1	38	— 6	32	1,670	80
C3	0.73	14,460	11,760	25.3	50	— 1	49	2,620	81
C4	0.73	17,960	9,790	27.1	28	+ 3	31	2,460	80
C5	0.73	14,250	9,950	34.2	50	— 1	49	3,200	80
C6	0.74	11,150	10,570	54.8	194	+ 2	196	5,560	81
C7	0.71	14,290	10,220	51.3	122	— 2	120	4,790	80
C8	0.73	11,430	8,920	75.0	246	— 2	244	6,860	82
C9	0.72	16,370	9,010	59.5	113	—13	100	5,220	81
C10	0.74	11,770	8,250	82.7	203	+ 2	205	6,740	81
Av.		13,880							

*Moisture content: Series A—13.0 per cent, Series B—13.1 per cent, Series C—15.0 per cent.
†Series A and B stress levels expressed as a percentage of the average ultimate strength of each series. Series C stress levels expressed as a percentage of the ultimate strength of the individual specimen.

Exponential regressions, with forced zero intercepts, were fitted to the creep-stress level data of each species by the method of least squares. The equations of the curves are in the form

$$\Delta\epsilon = 10^{(a + b\sigma_L)} - c$$

where: $\Delta\epsilon$ = drift corrected creep in 28-minute sustained-load period, σ_L + stress level, percentage of ultimate tensile strength, a, b = constants, and $c = 10^a$.

Linear regressions, of the form

$$\Delta\epsilon = a + b\sigma$$

(symbols as defined above)

were fitted to the creep-stress level data of each species in the 5 to 30 per cent stress-level regions. The exponential and linear regressions for each species are given in Table 4 and are shown with the experimental observations in Figs. 1, 2, 3, and 4.

The average strength of the angelique series C specimens was significantly lower than the average strength of the specimens in series A and B. The series C creep-stress level relationship also differed noticeably from those of series A and B. The angelique creep-stress level data were therefore analyzed in two separate groups.

The results obtained from the stepwise loading and the repetitive loading tests indicate that the threshold of permanent set is in the 25 to 30 per cent stress-level region for basswood and in the 30 to 35 per cent stress-level region for cedro branco. The results of these tests are not consistent enough to preclude the possibility that set occurs at lower stress levels than the limits given.

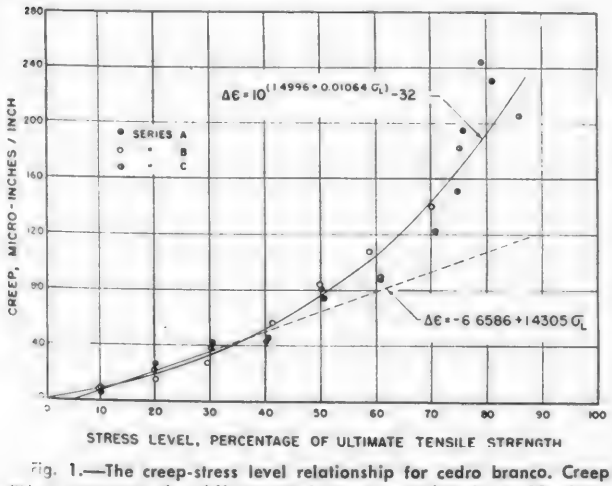

CREEP, MICRO-INCHES / INCH
STRESS LEVEL, PERCENTAGE OF ULTIMATE TENSILE STRENGTH
SERIES A
B
C
Δε = 10^(1.4996 + 0.01064 σL) − 32
Δε = −6.6586 + 1.4305 σL

Fig. 1.—The creep-stress level relationship for cedro branco. Creep values represent the drift-corrected creep occurring in a 28-minute sustained-load period. Stress levels are expressed as a percentage of the average ultimate strength of each series.

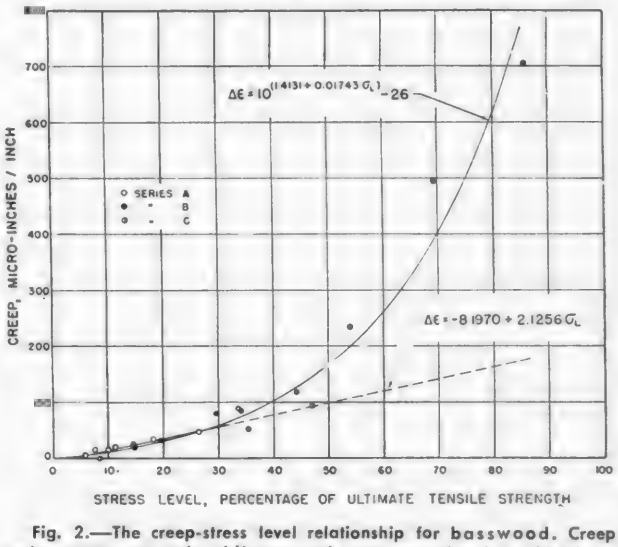

CREEP, MICRO-INCHES / INCH
STRESS LEVEL, PERCENTAGE OF ULTIMATE TENSILE STRENGTH
SERIES A
B
C
Δε = 10^(1.4131 + 0.01743 σL) − 26
Δε = −8.1970 + 2.1256 σL

Fig. 2.—The creep-stress level relationship for basswood. Creep values represent the drift-corrected creep occurring in a 28-minute sustained-load period. Stress levels are expressed as a percentage of the average ultimate strength of each series.

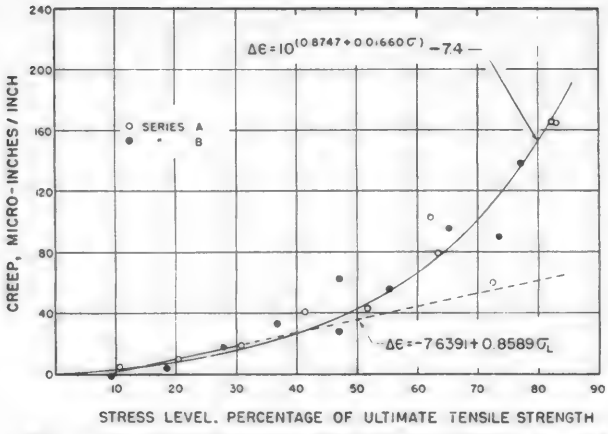

$\Delta\epsilon = 10^{(0.8747 + 0.01660\sigma)} - 7.4$
SERIES A
B
$\Delta\epsilon = -7.6391 + 0.8589\sigma_L$
CREEP, MICRO-INCHES / INCH
STRESS LEVEL, PERCENTAGE OF ULTIMATE TENSILE STRENGTH

Fig. 3.—The creep-stress level relationship for angelique, series A and B. Creep values represent the drift-corrected creep occurring in a 28-minute sustained-load period. Stress levels are expressed as a percentage of the average ultimate strength of each series.

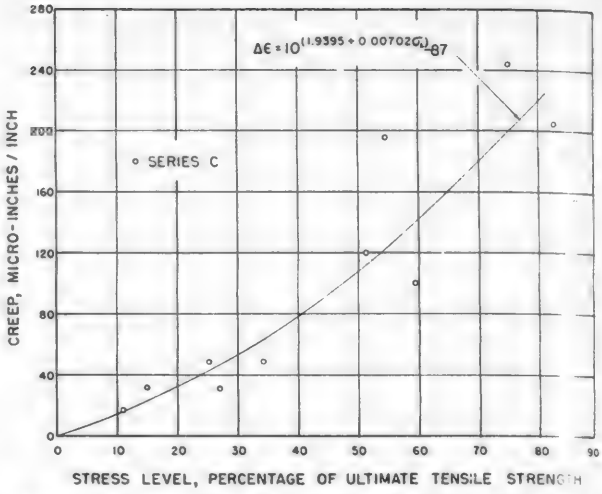

$\Delta\epsilon = 10^{(1.9395 + 0.00702\sigma_L)} - 87$
SERIES C
CREEP, MICRO-INCHES / INCH
STRESS LEVEL, PERCENTAGE OF ULTIMATE TENSILE STRENGTH

Fig. 4.—The creep-stress level relationship for angelique, series C. Creep values represent the drift-corrected creep occurring in a 28-minute sustained-load period. Stress levels are expressed as a percentage of individual ultimate strength.

Some of the test data obtained with cedro branco are given in Tables 5 and 6 to illustrate the two methods that were used to determine these threshold values.

Table 5 gives the results of six specimens tested repeatedly at their same respective stress levels. The relationship between creep and cycle number for each specimen is shown in Fig. 5. The straight lines in this figure were fitted visually. It was assumed that a significant trend existed between creep and test number when the creep values differed by more than ten microinches. This assumption was based on the results of similar tests with basswood at low stress levels. These tests indicated that, when there was no apparent trend between creep and test number, creep values were reproducible to within plus or minus five microinches. On this basis, specimens B9, B16, and C8 are designated as having undergone permanent set.

The unloaded strain measurements and creep values of a specimen tested in step-wise fashion at successively higher sustained loads are given in Table 6. The creep-stress level-set relationship for this specimen is shown in Fig. 6. The initial unloaded strain was measured four times over a 13-day period to determine the average unloaded or base strain and to determine the accuracy with which this strain could be reproduced. The specimen was then tested at the lowest stress level (expressed as a percentage of the average ultimate strength of the series).

After a recovery period, the unloaded strain was again measured and the specimen was tested at the next higher stress level. This procedure was repeated at each stress station. The difference between the unloaded strain measured at the end of the recovery period and the base strain was designated as set.

Three cedro branco specimens were tested statically to failure to explore the possibilities of correlating the results obtained from sustained-load tests with the results obtained from the usual static test. Another purpose was to check the feasibility of Ivanov's thesis (7) that load-strain curves are curvilinear from the beginning of loading. Each of these specimens was tested at a different rate of loading: 0.035 in. per min., 0.016 in. per min., and 0.008 in. per min. The load-strain information obtained for each of these specimens is given in Table 7.

Since it was not possible to plot the load against the actual strain measurement without losing a large portion of the sensitivity provided by the strain gage, the load was plotted against the differences between successive strain measurements (the method employed by Ivanov). These load against strain-difference curves are shown in Fig. 7.

When inspecting these curves, it

Table 4.—EXPONENTIAL AND LINEAR REGRESSIONS FOR THE BASSWOOD, CEDRO, AND ANGELIQUE CREEP-STRESS LEVEL DATA

Species	*Exponential regression**	*Linear regression**
Basswood	$\Delta\epsilon = 10^{(1.4131 + 0.01743\sigma_L)} - 26.0$	$\Delta\epsilon = -8.1970 + 2.1256\sigma_L$
Cedro branco	$\Delta\epsilon = 10^{(1.4996 + 0.01604\sigma_L)} - 32.0$	$\Delta\epsilon = -6.6586 + 1.4305\sigma_L$
Angelique		
Series A and B	$\Delta\epsilon = 10^{(0.8747 + 0.01660\sigma_L)} - 7.4$	$\Delta\epsilon = -7.6391 + 0.8589\sigma_L$
Series C	$\Delta\epsilon = 10^{(1.9395 + 0.00702\sigma_L)} - 87.0$	

* $\Delta\epsilon$ — Drift corrected creep in 28-minute sustained-load period, microinches per inch.
σ_L — Stress level, percentage of ultimate tensile strength.

Table 5.—CREEP DATA FOR SIX CEDRO BRANCO SPECIMENS TESTED REPEATEDLY AT THE SAME STRESS LEVEL

Series and specimen	Stress level*	Drift-corrected creep, 2-30 min.				
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
	%	Microinches per inch				
B15	20.2	16	15	13	17	20
B9	29.5	28	33	32	23	22
B16	41.4	57	50	37	39	--
C4	20.0	23	--	19	14	15
C7	30.2	39	41	33	--	33
C8	40.3	44	39	24	26	--

*Stress level expressed as a percentage of the average ultimate strength of the series.

Table 6.—RECOVERY AND CREEP DATA FOR CEDRO BRANCO NO. A15 TESTED IN STEP-WISE FASHION AT SUCCESSIVELY HIGHER STRESS LEVELS

Day	Unloaded strain	Set	Stress level*	Drift corrected creep 2-30 min.
	Microinches per inch	Microinches per inch	%	Microinches per inch
1	5432	--	0.0	
5	5438	--	0.0	
7	5434	--	0.0	
15	5438	--	10.3	
Base strain	5436			
17	5430	0	20.7	
20	5436	0	31.0	
22	5436	0	41.3	
25	5461	25	51.7	
27	5486	50	62.0	
34	5531	95	72.3	

*Stress level expressed as a percentage of the average ultimate strength of the series. Specimen tested immediately after the unloaded strain measurement.

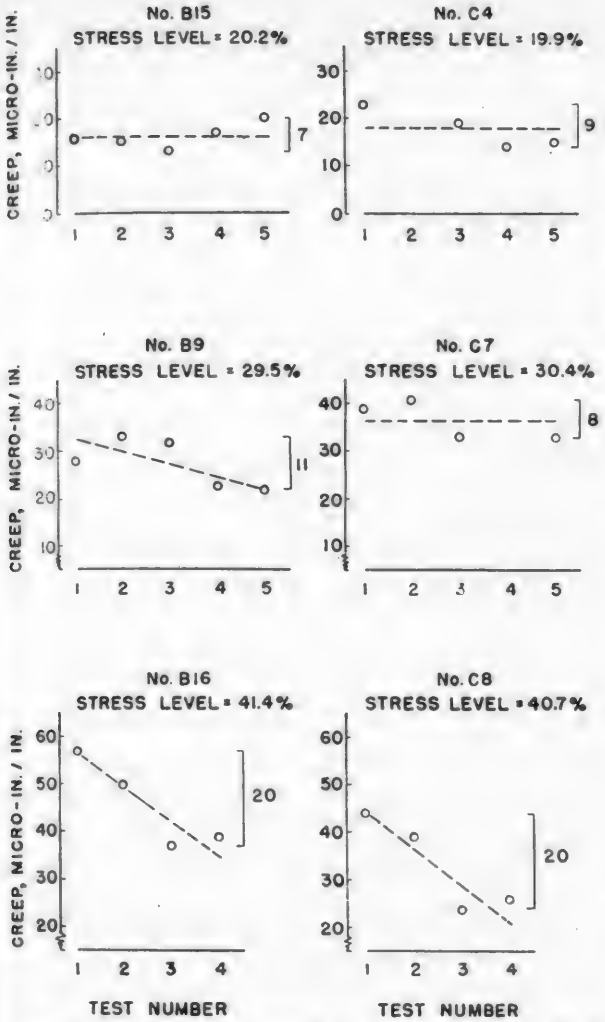


Fig. 5.—The relationship between creep and test number for six cedro branco specimens tested repeatedly at their same respective stress levels. Creep values represent the drift-corrected creep occurring in a 28-minute sustained-load period. Stress levels are expressed as a percentage of the average ultimate strength of each series.

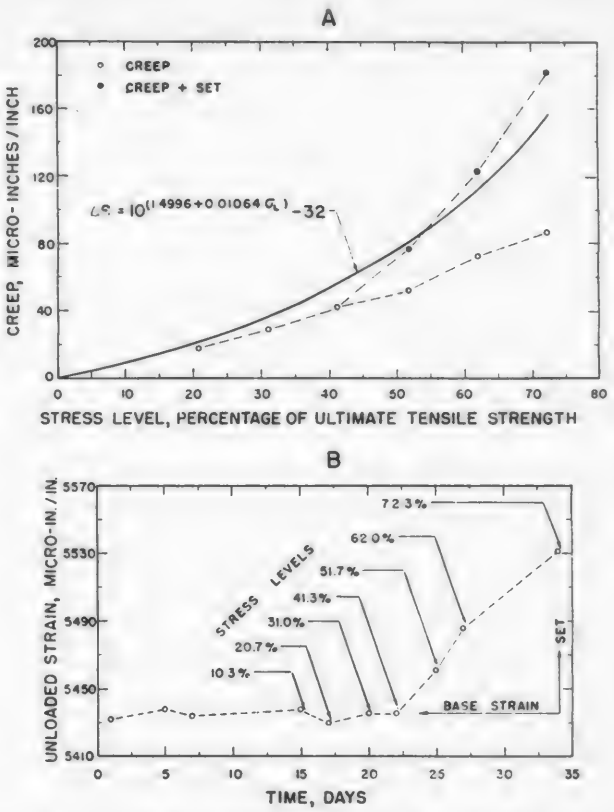


Fig. 6.—Creep-stress level-set relationships for a cedro branco specimen tested in stepwise fashion at successively higher stress levels. A. Comparison of the creep-stress level and the creep plus set-stress level relationships of this specimen with the average creep-stress level relationship of the species. B. The relationship between unloaded strain and stress level.

should be kept in mind that, with a material which behaves according to Hooke's Law (that is, stress proportional to strain), the differences between successive strain measurements would be constant up to the proportional limit, and the load against strain-difference relation would appear as a straight vertical line. The straight lines shown in Fig. 7 were graphically fitted, and only indicate the general trend of the data.

Discussion

An exploratory investigation of the ultimate tensile strengths obtained with the specimen used in this study and the new A. S. T. M. specimen (13) has indicated that the latter gives consistently higher strength values. The computed stress levels given in Tables 1, 2, and 3 may therefore be somewhat high.

It can be seen from Figs. 1, 2, 3, and 4 that the exponential regression, with forced zero intercept, describes the experimental data reasonably well. A comparison of the exponential and linear regressions indicates that the exponential regression approaches linearity at the lower stress levels. If it is assumed that the two regressions fit the experimental data equally well at the lower stress levels, it may be concluded that creep began between the 0 and 5 per cent stress levels in basswood and cedro, and between the 0 and 10 per cent stress levels in angelique (series A and B).

It is interesting to note that the exponential curves for basswood and cedro cross the linear regressions at

Table 7.—LOAD AND STRAIN DATA FOR THREE CEDRO BRANCO SPECIMENS TESTED STATICALLY TO FAILURE

Specimen No. A 11; Speed, 0.035 in./min.; Loading time, 13 min.		Specimen No. A 12†; Speed, 0.016 in./min.; Loading time, 31 min.		Specimen No. A 13; Speed, 0.008 in./min. Loading time, 5min.	
Load pounds	Strain microinches per inch	Load pounds	Strain microinches per inch	Load pounds	Strain microninches per inch
0	----	0	----	0	----
80	487	80	775	80	550
160	897	160	1201	160	1018
240	1312	240	1595	240	1465
320	1735	320	2014	320	1908
400	2160	400	2445	400	2330
480	2590	480	2871	480	2785
560	3024	560	3295	560	3243
640	3458	640	3728	640	3690
720	3913	720	4175	720	4148
800	4327	800	4608	800	4620
880	4761	880	5083	880	5096
960	5197	960	5543	960	5571
1040	5627	1040	6008	1040	6026
1120	6078	1120	6448	1120	6503
1200	6719*	1200	6934	1200	6990
1280	7133	1280	7409	1280	7480
1360	7541	1360	7887	1360	7994
1440	8051	1440	8397	1440	8541
1520	8505	1520	8857	1520	9236
1600	9112	1600	9104	----	----
1680	9758	1680	9675	----	----
1700‡	9919	1710‡	----	1585‡	9748

*Load range changed.
†Failure occurred outside the critical section.
‡Ultimate load.

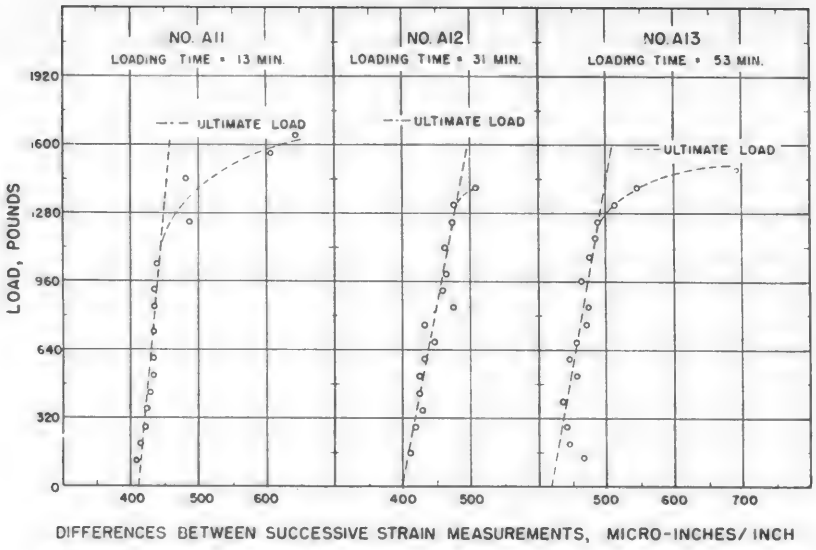


Fig. 7.—Load-strain difference curves for three cedro branco specimens tested statically to failure at different rates of loading.

about the same stress levels at which it was estimated that permanent set began. The distribution of the experimental points around the regressions suggests that a two-stage relationship, consisting of a linear regression up to the threshhold of set and a curvilinear regression thereafter, would be the most accurate description of the observed creep behavior.

Figs. 1 and 2 suggest that differences in specific gravity can not account for the entire observed differences in the magnitude of the creep response between species. For example, the average creep response for basswood, specific gravity 0.40, was 167 microinches per inch at the 50 per cent stress level. The average creep response for cedro branco, specific gravity 0.45, was 76 microinches per inch at this same stress level.

As would be expected, a linear relationship was found between stress and approximate initial strain (initial strain plus creep occurring in the first two minutes of the sustained-load period) for any given test series. Thus the creep-approximate initial strain relationships were very similar to the creep-stress level relationships shown in Figs. 1, 2, 3, and 4.

From Fig. 6 (which shows the creep-stress level relationship of a single specimen tested in step-wise fashion) it can be seen that, when previous set was added to the creep at a particular stress level, the resulting value fell reasonably close to the exponential curve of Fig. 1. This would seem to indicate the existence of a causal relation between creep and set, and also to indicate that initial strain tends to be fully recoverable. This proximity of the creep plus set values to the exponential curve provides support for the assumption used in the repetitive loading method of determining the threshold of set, the assumption being that set had occurred when a significant trend existed between creep and cycle number.

The stress level at which set began is not called the elastic limit for it seems reasonable to expect that this stress level will vary according to the duration of the sustained load. This would follow if the causal relation between creep and set suggested in Fig. 6 is the case. For then the threshold of set would be marked by a limiting creep value, and the sustained stress that would produce this value would depend on the sustained load period.

The general trends of the curves in Fig. 7 suggest that wood does not behave according to Hooke's Law in tension parallel to the grain. This is consistent with the results obtained in the sustained-load tests, which showed that creep began at very low stress levels. As the load is increased during static testing, the percentage of the total strain resulting from creep would be expected to increase.

According to Ivanov (7), the points at which the curves in Fig. 7 depart from a linear relationship are the safe long-term loads. Many more tests must be conducted before any definite statements can be made regarding the validity of this proposition.

Literature Cited

1. Australian Forest Products Laboratory, 1946–1954. Annual Reports. C.S.I.R.O., Div. of Forest Products, Australia.
2. Dietz, A. G. H., 1949. Short-time creep tests on Douglas-fir. Proc. For. Prod. Res. Soc., 3:352–360.
3. Grossman, P. U. A., and R. S. T. Kingston, 1954. The influence of stress on creep. C.S.I.R.O., Div. of Forest Products, Australia. Project T.P. 16–2.
4. Hermans, P. H., 1949. Physics and chemistry of cellulose fibers. Elsevier, New York.
5. Hetenyi, M., 1950. Handbook of experimental stress analysis. Wiley, New York.
6. Ivanov, G. M.,* 1938. Nachwirkende Formänderungen und Fliessgrenze bei Holz (After-effect strain and "limit of plastic flow" of wood). C. R. Acad. Sci. URSS, N.s. 19, Nr 6/7:545–552. (Literature review 41, Holz als Roh- und Werkstoff, 2(1):35. 1939.)
7. Ivanov, Iu. M., 1949. The new measure of the strength of wood and methods of its determination. Akademia nauk SSSR. Trudy institute lesa, 4:34–45. (Translated by H. P. Kipp, U. S. For. Prod. Lab. Translation No. 24. 1951.)
8. Johnson, J. B., 1930. Materials of construction. Ed. 7. Wiley, New York.
9. Kagi, H., 1953. Load-elongation curves in textiles, leather, and paper. Textil-Rundschau. 8(4):168–176. 8(5): 233–242. (Translated by H. P. Kipp, U. S. For. Prod. Lab. Translation No. 201. 1954.)
10. Lanza, G., 1909. Applied mechanics. Ed. 9. Wiley, New York.
11. Leadermann, H., 1943. Elastic and creep properties of filamentous materials and other high polymers. Textile Foundation Inc., Washington, D. C.
12. Markwardt, L. J., and T. R. C. Wilson. 1935. Strength and related properties of woods grown in the United States. U.S. Dept. Agr., Tech. Bul. No. 479.
13. ————, and W. G. Youngquist. 1956. Tension test methods for wood, wood-base materials, and sandwich construction. U. S. For. Prod. Lab. Report No. 2055.
14. Minami, Y., 1939. Tensile creep tests on wood. Journal Aeronautical Res. Institute, 174:23–27.
15. Radcliffe, B. M., 1955. A Method for determining the elastic constants of wood by means of electric resistance strain gages. Jour. For. Prod. Res. Soc., 5(1):77–80.
16. Tiemann, H. D., 1909. Some results of dead load bending tests by means of a recording deflectometer. Proc. Amer. Soc. Test Matl., 9:534–548.
17. ————, 1951. Wood technology. Ed. 3. Pitman, New York.
18. Wood, L. W., 1947. Behavior of wood under loading. Eng. News Record. 139(24):108–111.

*G. M. Ivanov and Iu. M. Ivanov are apparently the same, for the German transcription of the Russian Iurij (George), is Georg.

The Sorption of Water Vapor by Domestic and Tropical Woods[1, 2]

HOWARD A. SPALT
School of Forestry, Yale University

Moisture-sorption characteristics of four species at 90° F. determined in a precision evacuated apparatus are presented. Results confirm the existence of a distinct initial desorption isotherm, and indicate that considerable variation in hygroscopicity exists between species.

Introduction

PRESENT KNOWLEDGE OF THE BASIC hygroscopic nature of wood has been gained from studies involving relatively few species. For the most part, the materials investigated have been extracted and unextracted spruce wood and spruce chemical pulps. Much of the work carried out with wood has been concerned with the influence of conditioning and treatment upon the sorption isotherms and hysteresis. Although these intensive studies have served to define the basic sorption properties of wood, the variability in hygroscopicity between species is still relatively unexplored.

In addition to the direct result of gaining new information on equilibrium moisture content, a study of the sorption characteristics of several woods may also provide some insight into the magnitude of differences in cell-wall structure between species. This sorption study is being conducted on several domestic and tropical woods in an effort to evaluate possible differences between them. Results of tests carried out on initially air-dry spruce and three other species taken through two desorption and adsorption cycles from the initially green condition are presented in this paper.

Review of Previous Work

The earliest contributions to an understanding of the hygroscopicity of cellulosic materials were made by textile researchers. Investigations by Müller (2)[3] and Trouton (9) established a definite relationship between relative humidity and moisture sorption by cellulose. Masson and Richards (1) were the first to note that the desorption moisture content attained by cotton in equilibrium with a given relative vapor pressure was higher than the adsorption moisture content. This they attributed to the failure of the material to attain a true equilibrium. Urquhart and co-workers (11, 12, 13) subsequently showed hysteresis in water-vapor sorption to be a property of cellulose. Urquhart's theory (10) is that hysteresis is caused by the development of hydrogen bonds between hydroxyl groups on adjacent cellulose molecules that reduce the sites available to adsorb water. Some of these bonds remain permanently after formation, accounting for the irreversible loss of hygroscopicity upon initial drying. Other bonds are temporary due to the strain created in their formation, and are subsequently broken by the swelling of the cell wall upon readsorption of water, thus causing hysteresis.

Studies on a limited number of species have shown that the basic sorption characteristics found for cotton cellulose are also exhibited by wood. Stamm and Woodruff (8) compared the adsorption-desorption (hysteresis) ratio calculated for spruce wood tested in a vacuum apparatus with that compiled by Seborg (4) from non-vacuum tests, and concluded that the average of 0.83 for both tests is evidence that hysteresis is not influenced by the presence or absence of air. Reduction in the magnitude of hysteresis due to alternating adsorption and desorption in wood when exposed to fluctuating

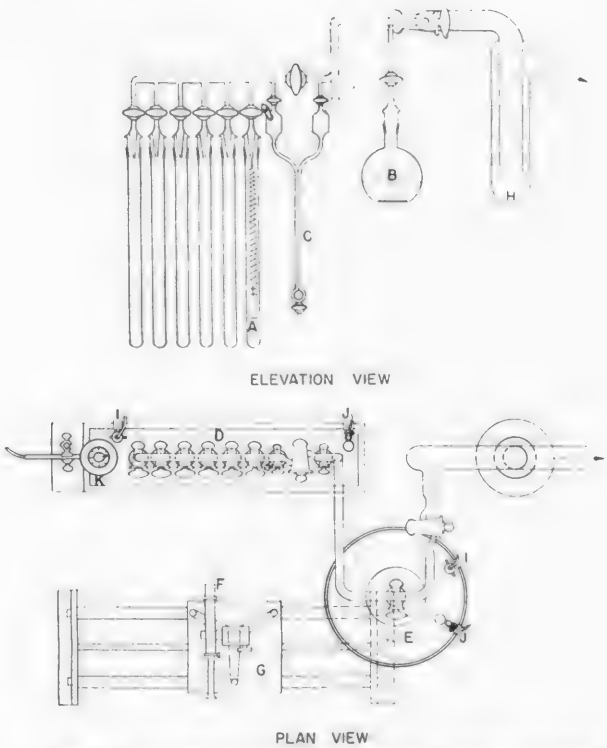


Fig. 1.—Elevation and plan views of the basic sorption apparatus. A, weighing tube; B, solution bulb; C, mercury manometer; D, constant-temperature bath housing weighing tubes and manometer; E, constant-temperature bath housing solution bulb; F, cathetometer; G, cathetometer stage; H, liquid nitrogen trap; I, immersion heaters; and J, thermostats.

[1] This research is part of a comprehensive study being conducted at the Yale School of Forestry in cooperation with the Office of Naval Research, Department of the Navy under Contract Nonr 609(13), Project NR 330-001, Properties of Tropical Woods.

[2] 1957 Wood Award Entry.

[3] Numbers in parentheses refer to literature cited.

The Author: Howard Spalt has a B.S. degree from Rutgers University and a M.F. degree from Yale University, where he is presently a candidate for the degree of Doctor of Forestry. He is a FPRS member.

relative humidity was found by Stamm and Loughborough (6). Schniewind (3) has found that beech in thicknesses up to 0.8 inch exhibits no significant reduction in hysteresis. Apparently, loss or gain of moisture under constant relative vapor pressure conditions is unidirectional.

Apparatus

An evacuated system was selected to carry out all sorption tests, since the removal of air accelerates vapor movement and thereby reduces the time required to attain equilibrium. Elevation and plan views of the system employed in this study are shown in Fig. 1. Wood specimens are suspended on calibrated quartz coils in the weighing tubes (A). Constant vapor pressures are provided by saturated salt solutions contained in the bulb (B). To assure saturation, the solutions are agitated by a magnet driven by a rotating magnetic field. Specimens are weighed by measuring the elongation of the calibrated coils. The actual vapor pressure prevailing throughout the system is determined by measuring the differential heights of the mercury menisci in the manometer (C).

The arrangement of the apparatus is shown in the plan view. Weighing tubes and manometer are maintained at 90° F. in the rectangular water bath (D). Constant temperature of the salt solutions is maintained by the circular water bath (E). Both baths are controlled within 0.1° F. by thermostatically operated heaters and continuous agitation. Measurements of coil elongation and manometer differentials are made with a cathetometer (F) accurate to 0.05 mm. The instrument is mounted on a stage (G) that travels on a level, finely-machined track, thus eliminating awkward leveling of the telescope at each measuring station.

Evacuation is accomplished by a mercury diffusion pump backed by a motor-driven piston pump, which forms a two-stage arrangement providing an ultimate vacuum of 10^{-4} to 10^{-5} mm. of mercury. A trap (H) immersed in liquid nitrogen effectively removes water vapor from the system and prevents heated mercury from entering.

Materials and Testing Procedure

Five specimens of white spruce and basswood, each from five different pieces, and three specimens from three different pieces each of redwood and a tropical hardwood, Santa Maria *(Calophyllum brasiliense)* were prepared. All material with the exception of white spruce was in the initially green condition. Thickness of the specimens was held constant at 2.0 ± 0.15 mm. The width and length were varied so as to obtain a dry weight of 1000 mg. or more. The load-elongation characteristics of the coils and the cathetometer enabled weighing specimens to 1 mg. Specimens with a dry weight in excess of 1000 mg. could therefore be weighed to 1 part in 1000, or to 0.1 per cent moisture content.

Specimens in the wet condition (the spruce specimens were first brought to the fully-swollen condition) were suspended in the weighing tubes, which contained several drops of distilled water at the bottom to minimize drying of the material during initial evacuation. A vacuum sufficient to seat the joints was drawn directly by the pumps. Further removal of air was accomplished after the system was lowered into the baths. The pumping was carried out indirectly so as not to dry the surfaces of the specimens by direct exposure to the trap.

When the control conditions had been established, periodic measurements of the manometer differential and coil elongations were taken. A criterion of three successive identical readings of coil elongation at intervals of 2 hours was established as the basis for equilibrium. Readings over a period in excess of 12 hours showed that this criterion was adequate except at the highest relative vapor pressure tested. Therefore, readings over an 8 hour span or longer were made to assure equilibrium at relative vapor pressures above 0.90.

Results

Equilibrium moisture contents were calculated on the basis of vacuum-dry weights. Dry weights of spruce in equilibrium with the vapor pressure of water at the boiling point of nitrogen (—320.8° F.) were found to be as low as those attained in an oven with the prevailing atmospheric vapor pressure at 212° F. Average relative vapor pressures provided in the weighing tubes by the salt solutions were determined and used to plot the equilibrium points except in the few cases where the solution temperatures at equilibrium were not identical with the control temperatures at which the solutions were calibrated. The actual readings of the vapor pressure in the system then served as a check on vapor pressure control. Sorption isotherms were drawn as smooth curves through the experimental points.

The fraction of the void volume of the swollen cell wall contributed by capillaries of various radii was calculated from second-cycle desorption isotherms and through use of the Kelvin equation by a method given by Stamm (5). Moisture contents were taken at 2 per cent moisture content intervals from the dry condition to the fiber saturation point for each species, were converted to fractions, and were transposed to the fractional volume of swollen wood substance by the equation

$$V = \frac{mg_o}{s}\left(\frac{1}{1+\frac{mg_o}{s}}\right)$$

where V equals the fractional volume occupied by water in the swollen cell wall, m equals the moisture content (weight basis) expressed as a fraction, g_o equals the density of wood substance taken as 1.46g/cc., and s equals the density of adsorbed water at the corresponding moisture content as determined by Stamm and Sebor (7).

The calculated fractional volumes

Table 1.—EXPERIMENTALLY DETERMINED MOISTURE CONTENT—RELATIVE VAPOR PRESSURE EQUILIBRIUM AT 90° F.

Species	First cycle				Second cycle			
	Desorption		Adsorption		Desorption		Adsorption	
	Relative vapor pressure	Moisture content (per cent)	Relative vapor pressure	Moisture content (per cent)	Relative vapor pressure	Moisture content (per cent)	Relative vapor pressure	Moisture content (per cent)
White Spruce*	0.940	29.2	0.940	24.7				
	0.863	22.6	0.863	17.0				
	0.780	18.7	0.780	15.2				
	0.612	13.7	0.612	11.1				
	0.323	7.7	0.323	6.6				
	0.193	6.0	0.193	4.9				
Basswood	0.940	29.6	0.940	21.9	0.940	28.7	-----	----
	0.863	21.3	0.863	15.8	0.863	20.9	-----	----
	0.780	18.3	0.780	13.1	0.780	16.7	0.801	14.4
	0.612	12.7	0.612	9.1	0.612	11.9	-----	----
	0.455	9.5	0.455	6.7	0.455	9.2	0.455	6.9
	0.174	4.5	0.174	3.8	0.174	4.4	0.174	3.6
Redwood	0.940	21.3	0.965	21.7	0.915	20.1	-----	----
	0.863	19.2	0.863	15.7	0.832	17.4	0.832	15.5
	0.780	16.4	0.780	12.1	0.766	15.3	-----	----
	0.612	12.2	0.612	9.5	0.605	12.2	-----	----
	0.455	10.1	0.455	7.6	0.455	9.7	0.455	7.4
	0.174	5.3	0.174	4.1	0.174	5.5	0.174	4.1
Santa Maria	0.940	33.0	0.965	25.0	0.915	24.5		
	0.863	26.0	0.863	18.0	0.832	20.9	0.832	17.9
	0.780	20.5	0.780	13.7	0.766	18.1		
	0.612	14.5	0.612	10.5	0.605	13.9	-----	----
	0.455	11.1	0.455	8.3	0.455	10.7	0.455	8.2
	0.174	5.2	0.174	4.4	0.174	5.5	0.174	4.5

*Material obtained in the air-dry condition. It was resaturated before testing and taken through one desorption-adsorption cycle.

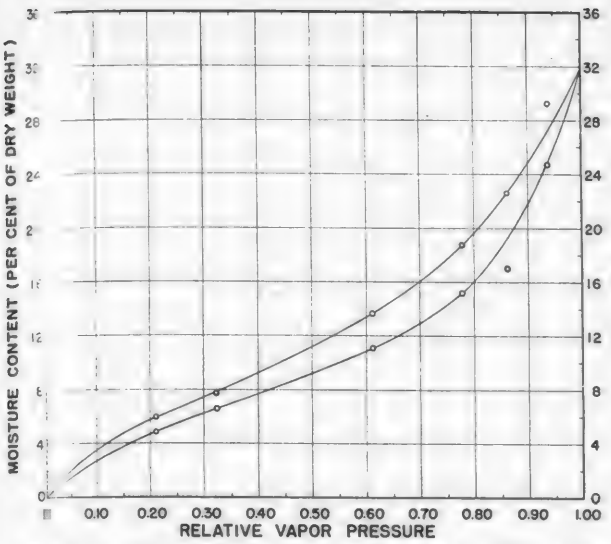

MOISTURE CONTENT (PER CENT OF DRY WEIGHT)
RELATIVE VAPOR PRESSURE
0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
0 4 8 12 16 20 24 28 32 36

Fig. 2.—Moisture content—relative vapor pressure equilibrium isotherms for previously air-dried white spruce at 90° F. The upper curve was obtained in desorption and the lower curve in adsorption.

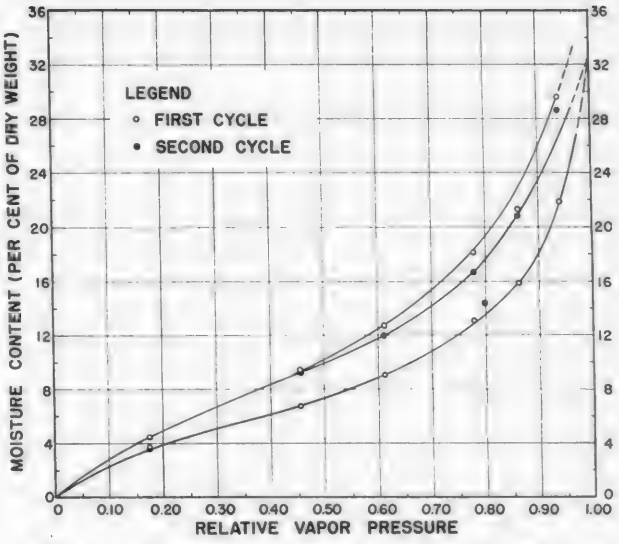

LEGEND
° FIRST CYCLE
• SECOND CYCLE
MOISTURE CONTENT (PER CENT OF DRY WEIGHT)
RELATIVE VAPOR PRESSURE
0 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
0 4 8 12 16 20 24 28 32 36

Fig. 3.—Moisture content—relative vapor pressure equilibrium isotherms for basswood at 90° F. tested from the initially green condition.

occupied by water (V) were then plotted against the corresponding moisture contents expressed as a per cent of vacuum-dry weight. The radii of capillaries in equilibrium with 22 relative vapor pressures between zero and 0.965 were calculated from the Kelvin equation,

$$r = \frac{2\sigma M}{d_o RT \ln\left(\frac{p_o}{p}\right)}$$

where r equals the radius of capillary in equilibrium with the given relative vapor pressure, σ equals the surface tension of water at 90° F. (70.78 dynes/cm.), M equals the molecular weight of water (18.02 g/mole), d_o equals the density of water (assumed to be 1 g/cc.), R equals the ideal gas constant (8.134×10^7 ergs per degree per mole), T equals temperature, degrees Kelvin (305.3° K), p_o equals the vapor pressure of water at 90° F., and p equals the vapor pressure of water in a capillary of radius r.

At each of the 22 relative vapor pressures, the second-cycle desorption equilibrium moisture content was determined from the isotherm and converted into units of V read from the curve of V vs. moisture content. By this means, the relationship between V and r was determined and plotted. The resulting curve was then graphically differentiated to obtain the rate of change of fractional liquid volume (dV) with the change in capillary radius (dr). From a plot of the relationship dV/dr and r, the contribution of capillaries of various radii to the void volume of the fully swollen cell wall was obtained.

The results that follow were obtained as a consequence of the general procedures outlined in the foregoing paragraphs. Moisture contents in equilibrium with the experimentally established relative vapor pressures for four species are given in Table 1. Due to minor differences in temperature of the salt solutions at equilibrium, the relative vapor pressures established by a particular salt are not necessarily identical. The experimental values are plotted for each species in Figs. 2 through 5. With relatively few exceptions, the points lie on well-defined, smooth curves. At relative vapor pressures above 0.90, several equilibrium points define a curve that becomes asymptotic to the 1.00 relative vapor pressure axis, indicating possible condensation of water vapor outside of the cell-wall capillaries. Pit membrane pores represent a possible source of such condensation. The extrapolation of the isotherms to the saturation axis therefore involves considerable indi-

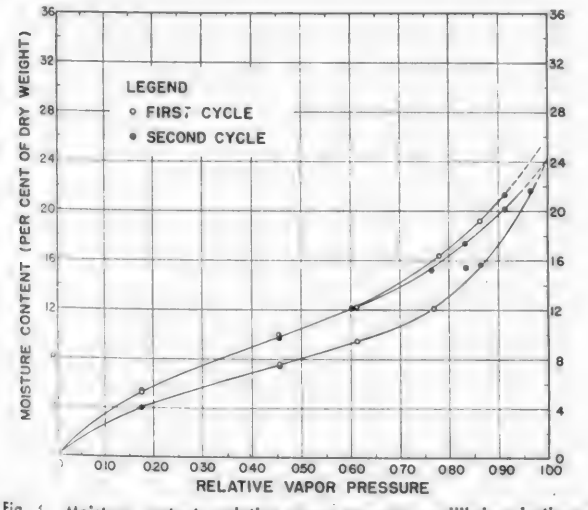

LEGEND
° FIRST CYCLE
• SECOND CYCLE
MOISTURE CONTENT (PER CENT OF DRY WEIGHT)
RELATIVE VAPOR PRESSURE
0 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
0 4 8 12 16 20 24 28 32 36

Fig. 4.—Moisture content—relative vapor pressure equilibrium isotherms for redwood at 90° F. tested from the initially green condition.

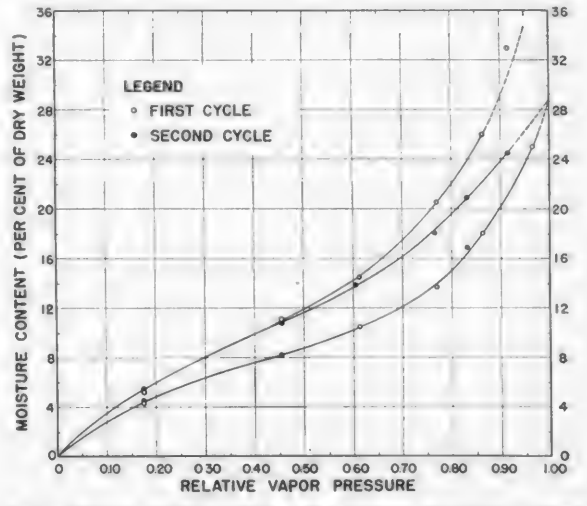

LEGEND
° FIRST CYCLE
• SECOND CYCLE
MOISTURE CONTENT (PER CENT OF DRY WEIGHT)
RELATIVE VAPOR PRESSURE
0 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
0 4 8 12 16 20 24 28 32 36

Fig. 5.—Moisture content—relative vapor pressure equilibrium isotherms for Santa Maria at 90° F. tested from the initially green condition.

Table 2.—EQUILIBRIUM MOISTURE CONTENTS AND HYSTERESIS RATIOS FOR SEVERAL SPECIES AT 90° F.

Species	Relative vapor pressure 0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	Average ratio
White Spruce										
Adsorption	2.8	4.8	6.4	7.8	9.3	10.9	13.0	16.0	21.6	
Desorption	3.6	5.8	7.5	9.4	11.2	13.4	16.1	19.6	24.8	
Ratio	.778	.827	.853	.830	.830	.813	.807	.816	.871	.825
Basswood										
Adsorption	2.4	4.0	5.2	6.2	7.4	8.9	10.9	13.6	18.0	
Desorption	2.9	5.1	6.8	8.4	10.0	11.8	14.2	17.6	23.4	
Ratio	.827	.784	.765	.738	.740	.754	.768	.773	.769	.769
Redwood										
Adsorption	2.7	4.5	5.8	7.0	8.2	9.4	10.7	13.2	16.4	
Desorption	3.6	5.8	7.6	9.1	10.5	12.1	12.9	16.4	19.7	
Ratio	.750	.776	.763	.769	.781	.777	.829	.805	.832	.787
Santa Maria										
Adsorption	2.8	4.9	6.4	7.6	8.8	10.3	12.1	15.0	20.2	
Desorption	3.6	6.0	8.1	10.0	11.7	13.7	16.1	19.6	23.8	
Ratio	.778	.817	.790	.760	.752	.752	.751	.765	.849	.779

vidual judgement and results in fiber-saturation-point values of doubtful significance.

Hysteresis ratios were calculated from adsorption and desorption moisture contents interpolated from the stable isotherms at each 10 percentile relative vapor pressure, and are compiled in Table 2. The 9 ratios thus obtained for each species were then averaged to obtain a measure of the magnitude of hysteresis for each species.

The per cent liquid volume (V) of the swollen cell wall at each moisture content is shown in Fig. 6. The relationship between V and capillary radius (r) at selected relative vapor pressures as determined from this curve and the Kelvin equation is plotted for spruce in Fig. 7. From the slope (dV/dr) of this curve at several values of capillary radius, the change in fractional liquid volume with change in radius was obtained. The vertical line of 0.4mμ radius represents the approximate minimum radius of capillary in which water molecules (0.38mμ in diameter) can enter. The range of capillary radii at each quartile percentage and at 95 per cent of void volume for each species is given in Table 3.

This method of calculating fractional void volumes is attended with appreciable error. The Kelvin equation applies here only to capillaries of relatively large dimensions, in comparison with those of the water molecule, in which there is little intermolecular attraction between adsorbate and substrate. The high densification of adsorbed water in cellulosic materials, particularly at low moisture contents, is evidence of the violation of this assumption. Nevertheless, differences shown between species give evidence of the nature of differences in cell-wall capillarity.

Discussion

The three species carried through two sorption cycles from the initially green condition exhibit an open loop at the upper limit of relative vapor pressure in the first cycle. This confirms the existence of a substantially higher initial desorption isotherm at high relative vapor pressures, and demonstrates the irreversible loss of hygroscopicity upon initial drying. Below 0.50–0.60 relative vapor pressure, the initial and second desorption isotherms converge to a common curve, which indicates that the permanent lateral bonding of cellulose molecules occurs during early stages of drying.

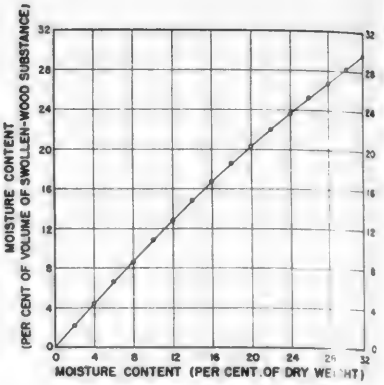


Fig. 6.—Relationship between moisture content of wood on a dry-weight basis and moisture content on a swollen-volume-of-wood basis.

The average hysteresis ratio of 0.825 for spruce agrees closely with the value of 0.83 obtained by Stamm and Woodruff (8) and Seborg (4), and lends confirmation to the successful control of temperature fluctuations in the sorption test. Inadequate control of temperature would result in a higher hysteresis ratio as a result of oscillating sorption. Average hysteresis ratios for basswood, Santa Maria, and redwood are considerably lower than for spruce, which suggests that the magnitude of hysteresis varies between species. Variability between species in cell-wall structure probably accounts for differences in the proportion of hydroxyl groups undergoing reversible bonding upon drying.

A comparison of the stable desorption isotherms and the distribution of capillary radii (Table 3) for these four species suggests the nature of hygroscopic variation. The equilibrium moisture content for basswood in desorption falls steeply with decreasing relative vapor pressure at the higher levels of vapor pressure, while in contrast, that for redwood exhibits a relatively small change with decreasing vapor pressure. The contribution of large capillaries to the void (water-filled) volume of the swollen cell wall in basswood is substantially greater than in redwood. Since the sorption isotherm for redwood closely corresponds to that of spruce at the lower relative vapor pressures, the divergence

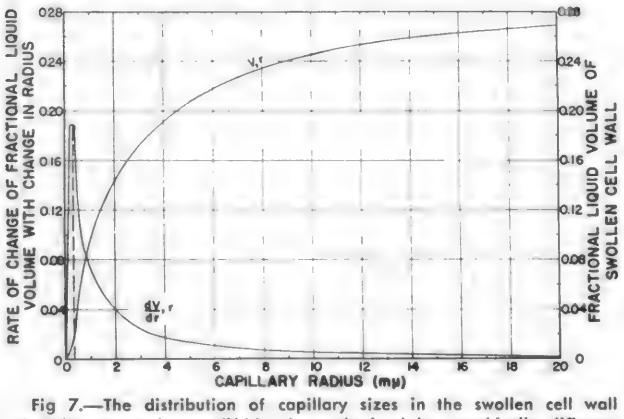

RATE OF CHANGE OF FRACTIONAL LIQUID VOLUME WITH CHANGE IN RADIUS
FRACTIONAL LIQUID VOLUME OF SWOLLEN CELL WALL
V,r
dV, r
dr
CAPILLARY RADIUS (mμ)

Fig 7.—The distribution of capillary sizes in the swollen cell wall of white spruce (curve dV/dr, r) as obtained by graphically differentiating the curve V,r expressing the relationship between fractional void volume and capillary radius in millimicrons (mμ).

Table 3.—UPPER LIMIT OF CAPILLARY RADIUS MAKING UP 25, 50, 75, AND 95 PER CENT OF THE TOTAL VOID VOLUME OF THE SWOLLEN CELL WALL*

Species	Per cent of total void volume 25	50	75	95
	Upper limit of capillary radius (mu)			
Spruce	0.6	1.7	5.6	14.7
Basswood	0.8	2.1	5.5	15.3
Redwood	0.5	1.5	3.6	10.0
Santa Maria	0.6	1.5	4.0	12.5

*Assuming the total void volume of the cell wall is made up of capillaries of radii up to 20 mu.

of redwood in the high relative vapor pressure range is apparently due to an unusually small proportion of large capillaries in the void volume of the cell wall.

Calculation of the capillary size distribution is predicated upon the sorption characteristics of the wood, and provides differentiating between nonexistent capillaries and capillaries unavailable for the condensation of water. Because of the high extractive content of redwood, it would appear reasonable that voids in the cell walls are obstructed with extraneous material, thereby reducing the capillary voids accessible to water. The fact that the desorption isotherm is similar to spruce at low moisture contents is evidence that the extractive material exists primarily in the larger capillaries. Such would be the case if the extractives are composed of large molecules that are too bulky to be accommodated in small capillaries.

The contrast provided by the isotherms of basswood and redwood gives support to the belief that a general description of the moisture-sorption characteristics of wood based upon the results obtained on a few species cannot be precise. It is to be expected that differences from species to species in cell-wall structure and capillarity, lateral intermolecular bonding, and extraneous-matter content will be reflected in variations in the moisture content-relative vapor pressure relationship and in the magnitude of hysteresis. Dissimilarity in shrinkage and moisture diffusion between woods of similar specific gravity are probable effects of variable hygroscopicity. The variations shown here between a few species demonstrate the need for a comprehensive study of the hygroscopic nature of individual species.

Summary and Conclusions

Moisture sorption tests on white spruce, basswood, redwood, and Santa Maria were carried out at 90° F. in a precision, evacuated apparatus. The results of tests on initially green material confirmed the existence of distinct initial desorption isotherms above 0.50 relative vapor pressure. The convergence of the first and second cycle desorption isotherms to a common curve indicates that the formation of permanent lateral bonds between cellulose molecules occurs in the early stages of initial drying.

Variation found in the magnitude of hysteresis between species is thought to be due to differences in the extent of reversible hydrogen-bond development between adjacent cellulose molecules.

The dissimilarity in the sorption isotherms of basswood and redwood reveals a strikingly different pattern of distribution of cell-wall capillaries in these two species and demonstrates that the sorption properties of wood cannot be described precisely from the results of tests on one or two species.

Literature Cited

1. Masson, O., and E. S. Richards. 1906. On the hygroscopic action of cotton. Royal Soc. Proc. (London) A78:412–429.
2. Müller, E. 1882. Über die Abhängigkeit des Wassergehaltes der Faserstoffe von dem Feuchtigkeitsgehalte der Atmosphäre. Dinglers Polytech. J. 245: 210–211.
3. Schniewind, A. P. 1956. Sorption hysteresis in relation to wood thickness. For. Prod. J. 6:225–229.
4. Seborg, C. O. 1937. Hysteresis in water sorption by paper-making materials. J. Ind. Eng. Chem. 28:1245–1250.
5. Stamm, A. J. 1946. Passage of liquids, vapors, and dissolved materials through softwoods. U.S.D.A. Tech. Bull. 929. 80 pp.
6. Stamm, A. J., and W. K. Loughborough. 1935. Thermodynamics of the swelling of wood. J. Phys. Chem. 39: 121–132.
7. Stamm, A. J., and R. M. Seborg. 1935. Adsorption compression on cellulose and wood. I. From density measurements in benzene. J. Phys. Chem. 39: 133–142.
8. Stamm, A. J., and S. A. Woodruff. 1941. A convenient six-tube vapor sorption apparatus. J. Ind. Eng. Chem. Analytical Ed. 13:836–838.
9. Trouton, F. T. 1906. The vapor pressure in equilibrium with substances holding varying amounts of moisture. Royal Soc. Proc. (London) A77:292–314.
10. Urquhart, A. R. 1929. The mechanism of the adsorption of water by cotton. J. Text. Inst. 20:T125–T132.
11. Urquhart, A. R., and A. M. Williams. 1924. Moisture relations of cotton. I. The taking up of water by raw and soda-boiled cotton at 20° C. J. Text. Inst. 15:T138–T143.
12. Urquhart, A. R., and N. Eckersall. 1930. The moisture relations of cotton. VII. A study of hysteresis. J. Text Inst. 21:T499–T510.
13. Urquhart, A. R., W. Bostock, and N. Eckersall. 1932. The moisture relations of cotton. VIII. The effect of processing. J. Text. Inst. 23:T135–T149.

The Distribution of Dihydroquercetin and a Leucoanthocyanidin in a Douglas-Fir Tree[1]

WILLIAM V. HANCOCK

Graduate School[2], University of British Columbia, Vancouver

A Douglas-fir tree was analyzed by colorimetric methods for the quantitative distribution of a leucoanthocyanidin and dihydroquercetin from the bark to the pith at different heights. The physical relationship provided information on the biological relationship, particularly with regard to heartwood formation.

Introduction

THE PHYSIOLOGY OF THE CONVERSION of sapwood to heartwood in trees is not completely understood as yet. The effect on wood as a raw material, however, has been observed and made use of for a long time. For example, the sapwood of trees is known to be very susceptible to attack by wood-destroying organisms, while heartwood exhibits a range of susceptibility from being very prone to attack to almost complete immunity over long periods.

It has been suggested by Chattaway (3)[3] that the parenchyma cells in the wood rays undergo a period of greatly increased activity just prior to their death. This occurs at the sapwood-heartwood boundary, and the dispersion through the wood of the cell contents after death converts the sapwood in that region to heartwood.

The extractive content of the wood of some species increases from the pith to a maximum at the sapwood-heartwood boundary, and is lower in the sapwood. Kennedy and Wilson (7) have shown that this is true for the flavanone, dihydroquercetin in Douglas-fir.

[1] 1957 Wood Award Entry.

[2] [illegible] facilities of the Vancouver Laboratory, Forest Products Laboratories of Canada, were drawn upon in this study..

[3] Numbers in parentheses refer to literature cited.

The Author: William Hancock received his B. S. degree in Forestry in 1949 from the University of British Columbia, and was then on the overseas sales staff of MacMillan & Bloedel, Ltd. until 1954. He received his M.F. in Wood anatomy and properties from the U. of B. C. in 1956, and is currently working toward his Ph.D.

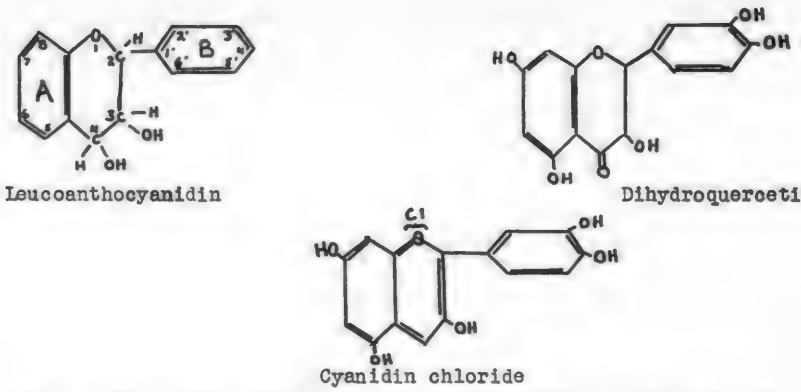


Fig. 1.—Basic structure of leucoanthocyanidin, cyanidin chloride, and dihydroquercetin.

In the course of experimental work on the determination of dihydroquercetin at the Vancouver laboratory of the Forest Products Laboratories of Canada, it was found that Douglas-fir wood contained a substance, soluble in methanol, which was converted to cyanidin chloride on treatment with acid (2). This substance appears to be a leucoanthocyanidin, although the structure has not yet been determined. For the purposes of this paper, this substance, although not yet fully characterized, will be referred to as a leucoanthocyanidin.

Leucoanthocyanidin is a generic term that denotes a rather loosely defined group of colorless phenolic compounds, widely distributed throughout higher plants, which yield anthocyanidins on treatment with aqueous or alcoholic acid. The anthocyanidins, which are the coloring materials found in many plants, may be detected by the color they impart to the extracting solvent during analysis.

Leucoanthocyanidins have frequently been held to be the precursors of plant anthocyanidins. Krugman and others (6), however, furnish examples where leucoanthocyanidins were found in plant material that could not serve as precursors for the anthocyanidins found in the same material.

Hillis (4) suggests that leucoanthocyanidins and anthocyanidins may have a common precursor, and that the leucoanthocyanidins play an important part in the respiration of the living cells in a tree, thereby giving rise to various extractives, including flavones and anthocyanidins.

According to King and Clark-Lewis (5), the basic structure of leucoanthocyanidins is as shown in Fig. 1. The various individuals differ in the pattern of hydroxylation of rings A and B.

Dihydroquercetin (3,3',4',5,7-pentahydroxyflavanone), from Douglas-fir, and cyanidin chloride (3,3',4',5,7-pentahydroxyflavylium chloride) both exhibit the same basic ring structure as the leucoanthocyanidins. In addition, cyanidin chloride has the same hydroxylation pattern on rings A and B as has dihydroquercetin. The cyanidin chloride obtained from Douglas-fir must have been formed from a substance with the same ring structure and hydroxylation pattern as dihydroquercetin.

In view of the postulated conversion of leucoanthocyanidins into heartwood extractives put forward by Hillis (4), and of the close chemical relationship between dihydroquercetin and cyanidin chloride, it was decided to analyze a Douglas-fir tree quantitatively for leucoanthocyanidin and for dihydroquercetin distribution.

A knowledge of the physical distribution of such substances should aid in establishing biological relationships and in furthering knowledge on the mechanism of heartwood formation.

Experimental

Raw Materials: The tree selected for analysis was a dominant Douglas-fir of 15 inches d.b.h. and 84 feet tall. It had 47 annual rings at breast height, and was estimated to be about 52 years old. Growth was vigorous, the outermost inch containing eight rings. The sapwood was wide, averaging about 2½ inches, and the sapwood-heartwood boundary was well delineated.

The tree was felled in mid-September before the first frost. The summerwood band appeared to be still in the process of formation. Sections approximately 4 inches thick were cut at 4½ feet and every 10 feet to 64½ feet. The section at 14½ feet was discarded because of the presence of a knot cluster, and a section was taken at 15 feet. The sections were immediately transported to the laboratory, wrapped in aluminum foil, and placed in a freezer at —20° C. to minimize chemical changes. Elapsed time from felling to placing the last section in the freezer was just under one hour.

Preparation of Wood Samples: A strip 1 inch wide was sawn from each section, from the bark to the pith, centered on a diameter. The upper and lower inches were sawn off, and the middle section was used for the experiment. This was further sawn into two sections, each approximately 1 inch thick, to facilitate accurate division into growth increments. The sections were divided into growth increments, or groups of increments, as set out in Table 1, to provide wood meal for analysis. The meal was prepared by grinding in a Wiley mill until the sample passed a 40-mesh screen. Some sapwood portions were too wet to grind properly. These were freeze-dried to 8 to 10 per cent moisture content and then ground. All samples were stored in the freezer, and were removed a short time before analysis to permit the material to warm to room temperature.

Determination of Dihydroquercetin: The method used for the quantitative determination of dihydroquercetin was that developed at the Vancouver laboratory (1). The quantities recommended were modified because of the small size of the samples being tested. The modified system was carefully checked against the original and gave the same results on a reproducible basis.

Four hundred milligrams, ±0.1 milligram, of wood meal were placed in a 125 ml. Erlenmeyer flask with 10 ml. of water. The flask was fitted with an air condenser, and was heated in a rapidly boiling water bath for 1 hour. The water was decanted through a fritted-glass funnel into a 25-ml. volumetric flask. The process was repeated for 1 hour with an additional 5 ml. of water and for two successive 30-minute periods with 3 ml. portions of water. After each heating, the water was decanted into the volumetric flask. The wood meal was washed from the Erlenmeyer flask into the funnel, and was washed down with sufficient water to bring the total to 25 ml.

A 1-ml. aliquot of the extract was placed in a pyrex test tube with 0.5 gm. ±0.001 gm. of zinc, 2 ml. of acetone and 1 ml. of glacial acetic acid were added. The mixture was stirred, then heated at 65° C. ± 0.5° C. for 40 minutes in a water bath. The liquid was decanted from the zinc, and the test tube was washed twice with a total of 10 ml. of acetone. One ml. of concentrated hydrochloric acid was added, with mixing, and the volume was adjusted to 25 ml. with acetone.

After five minutes, the color intensity developed was measured on a Fisher electrophotometer using filter B (525 mμ range). The time of measurement of color must be carefully controlled, because peak intensity is reached in 4½ to 5 minutes and begins to fade rapidly after 10 minutes.

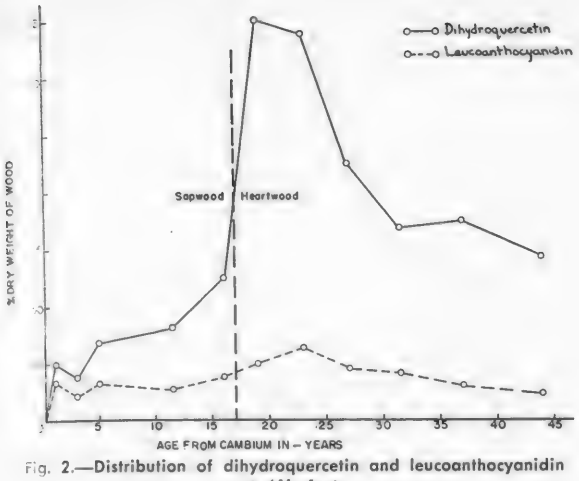


Fig. 2.—Distribution of dihydroquercetin and leucoanthocyanidin at 4½ feet.

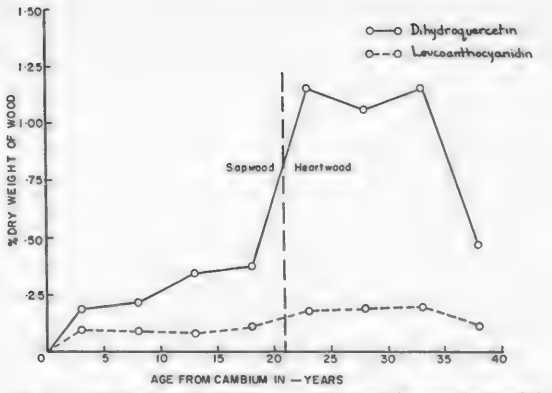


Fig. 3.—Distribution of dihydroquercetin and leucoanthocyanidin at 15 feet.

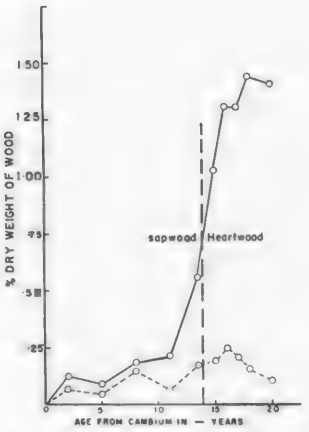


Fig. 4.—Distribution of dihydroquercetin and leucoanthocyanidin at 54½ feet.

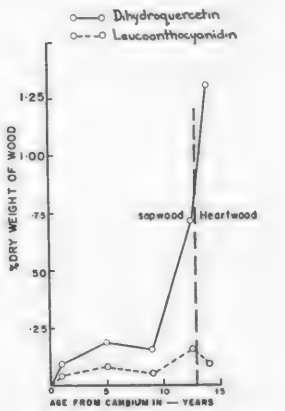


Fig. 5.—Distribution of dihydroquercetin and leucoanthocyanidin at 64½ feet.

The amount of dihydroquercetin present was determined from a calibration chart previously prepared by using standard solutions of pure dihydroquercetin. The quantity present was then adjusted for the moisture content of the wood tested.

Determination of Leucoanthocyanidin: The method of extraction of leucoanthocyanidins and their quantitative determination, as described by Hillis (4), was used with modifications. Normal butyl alcohol was substituted for isopropyl alcohol, and the test tube was fitted with a sealed air condenser. The high boiling point of the butyl alcohol, together with the condenser, prevented any pressure build-up within the tube. The solvent-wood ratio was adjusted to place the color intensity at the most sensitive portion of the measuring scale of the Fisher electrophotometer.

One hundred milligrams of wood meal were placed in the tube with 10 ml. of normal butyl alcohol and 2 ml. of 3N HCL. The condenser was fitted, and the tube was heated in boiling water for exactly 40 minutes with occasional shaking. The filtrate was cooled and diluted to 25 ml., and the color intensity was measured on a Fisher electrophotometer using filter B (525 mμ range). The amount of leucoanthocyanidin present was determined from a color calibration chart prepared from a sample of the substance believed to be leucoanthocyanidin isolated from Douglas-fir wood by Barton, Finlayson and Gardner (2). The quantities were adjusted for the moisture content of the wood under test

Results

Because of time limitations, only four sections were analyzed; they were those taken at heights of 4½ feet, 15 feet, 54½ feet and 64½ feet. The results obtained, expressed in terms of percentage of weight of dry wood, are given in Table 1 and are expressed graphically in Figs. 2 to 5.

Growth increments 7 to 9, inclusive, from the section taken at 4½ feet were divided into summerwood and springwood, and separate extractions were run. Expressed in terms of percentage dry weight, both types of wood contained essentially the same amount of dihydroquercetin, but the springwood contained approximately twice as much leucoanthocyanidin as did the summerwood. Leucoanthocyanidin extractions were run separately on the summerwood and springwood of growth increments 5, 20 and 30. In each case, the springwood contained two or more times as much leucoanthocyanidin as did the summerwood.

Table 1.—LEUCOANTHOCYANIDIN AND DIHYDROQUERCETIN PRESENT, IN TERMS OF PERCENTAGE OF DRY WEIGHT OF WOOD

Growth Increment Number	Dihydroquercetin, Per cent	Leucoanthocyanidin, Per cent
Section at 4½ feet		
1– 2	0.250	0.170
3– 4	0.188	0.110
5– 6	0.344	0.165
10–14	0.406	0.135
15–17	0.625	0.195
18–21	1.750	0.250
22–25	1.688	0.320
26–29	1.125	0.235
30–34	0.844	0.210
35–40	0.875	0.155
41–47	0.719	0.115
Section at 15 feet		
1– 5	0.188	0.095
6–10	0.219	0.090
11–15	0.344	0.080
16–20	0.375	0.110
21–25	1.156	0.180
26–30	1.063	0.195
31–35	1.156	0.200
36–41	0.469	0.115
Section at 54½ feet		
1– 3	0.125	0.070
4– 6	0.094	0.050
7– 9	0.188	0.150
10–12	0.219	0.070
13–14	0.563	0.175
15	1.031	0.195
16	1.313	0.250
17	1.313	0.205
18	1.438	0.165
19–22	1.406	0.105
Section at 64½ feet		
1– 3	0.094	0.035
4– 7	0.188	0.075
8–11	0.156	0.050
12–13	0.719	0.160
14	1.313	0.090

One possible answer to the difference in leucoanthocyanidin content between summerwood and springwood was that the leucoanthocyanidin was contained in the wood rays. The volume of ray material would be expected to be constant for adjacent equal volumes of summerwood and springwood, but a given volume of summerwood would weigh more than a similar volume of springwood.

To check this possibility, sections 40μ thick were cut across the sapwood-heartwood boundary from a piece freshly removed from the stored 4½-foot section. The leucoanthocyanidin is soluble in some alcohols, but apparently not in water. Concentrated HCl was added to a section, which had been mounted on a slide and observed under a dissecting microscope. The leucoanthocyanidin was apparently converted in place into cyanidin chloride, because the rays very quickly turned reddish-purple while surrounding tissue did not. The test was repeated with many sections, and the results were consistent.

An attempt was made to determine the distribution of dihydroquercetin in the wood tissues. Sections 20μ thick were cut, and heartwood portions were dissected into material that contained no rays and that which contained rays with small amounts of tracheid material. Dihydroquercetin extractions were run on a semimicro scale, and both portions gave strong positive tests.

Portions of inner bark from different heights in the tree were freeze-dried, ground, and analyzed for leucoanthocyanidin. Because of the great quantities present, the amount of dried bark extracted was reduced to 10 mgm. Some readings were still beyond the range of the measuring instrument until further dilution was made. Only rough estimates of quantity were possible on the basis of the work done, but these indicated the percentage of leucoanthocyanidin in inner bark of this tree to be about 10 per cent at 64½ feet, increasing to about 20 per cent at 4½ feet, based on dry weight of bark.

Discussion

Figs. 2 to 5 show that, in general, the concentration of leucoanthocyanidin in the wood of the tree under study is greatest at the sapwood-heartwood boundary, the site postulated by Chattaway as that of greatest physiological activity in the ray parenchyma. The distribution of dihydroquercetin follows the same general pattern, but at a much higher level, quantitatively. Dihydroquercetin is apparently distributed throughout the woody tissue, whereas the leucoanthocyanidin appears to be confined to the ray parenchyma. The inner bark apparently contains a high percentage by weight of leucoanthocyanidin.

The sample analyzed is too small for any conclusions to be drawn. It is suggested, however, that the inner bark serves as a reservoir of leucoanthocyanidin, which is taken up as needed by the ray parenchyma and utilized, one of the end products being dihydroquercetin. This dihydroquercetin could then diffuse from the ray parenchyma as part of the process of heartwood formation.

Literature Cited

1. Barton, G. M. and J. A. F. Gardner. 1956. Determination of dihydroquercetin in Douglas-fir and Western Larch wood. Paper presented at Northwest Regional Meeting, American Chemical Society, Seattle, June.
2. Barton, G. M., A. J. Finlayson and J. A. F. Gardner. Unpublished results.
3. Chattaway, M. M. 1952. The sapwood/heartwood transition. Australian Forestry, Vol. XVI, No. 1, pp. 25–34.
4. Hillis, W. E. 1956. Leucoanthocyanins as the possible precursors of extractives in woody tissue. Australian Journal of Biological Sciences, Vol. 9, Number 2, pp. 263–28
5. King, F. E. and J. W. Clark-Lewis. 1955. The constitution and synthesis of Leucoanthocyanidins. Journal of the Chemical Society, October. pp. 3384–3388.
6. Krugman, S. 1956. The Anthocyanin and Leuco-anthocyanins of sugar pine seedlings. Forest Science, Vol. 2, No. 4, Dec.
7. Wilson, J. W., and R. W. Kennedy. 1956. Variation in taxifolin content of a Douglas-fir stem exhibiting target ring. Forest Products Journal, Vol. 6, Number 6, pp. 230–231

Some Recent Advances in Pine Gum Chemistry[1]

JOHN C. BRAUN and E. L. PATTON

Research Chemist; Head, Naval Stores Research Section, Naval Stores Station, Southern Utilization Research and Development Division, U. S. Department of Agriculture, Olustee, Fla.

The research progress in pine gum chemistry is traced, with a description of utilization research used to find new uses for rosin and turpentine, for their components, or for chemical derivatives.

Introduction

PINE GUM, or more properly oleoresin, is the viscous solution of resin acids, terpenes and other materials that is exuded by various species of pine when they are wounded. In the United States, only the longleaf and slash pines growing in the southeastern states yield enough gum to be worked commercially. The working of these pines to produce pine gum and the cleaning and steam distillation of this gum to make turpentine and rosin make up what is known as the gum naval stores industry.

The gum naval stores industry has made tremendous technical advances during the last 20 years. The U. S. Forest Service has developed improved methods of turpentining which increase gum yield, reduce labor, and conserve the value of the whole tree for other uses (Fig. 1). At the same time, the Olustee Naval Stores Station of the Agricultural Research Service has introduced improved methods for processing the gum to produce better turpentine and rosin at lower cost. These research developments have been

Fig. 1.—Bark is chipped from the trunk of a Southern pine, and the exposed surface is sprayed with sulfuric acid to stimulate the flow of gum.

[1] Presented at Session XI, Chemical Utilization, FPRS 11th National Meeting, June 23-28, in Buffalo, N. Y.

The Authors: John C. Braun received both his B. S. and Ph. D. degrees from the University of Florida. He joined the Fundamental Research Unit at the Naval Stores Station following graduation in 1955. He is engaged in research dealing with composition and properties of turpentine.

E. L. Patton, a graduate of the Georgia Institute of Technology, spent six years with private industry before joining the Naval Stores staff in 1933. He was named head of the station in 1947 after returning from service in World War II.

widely adopted by the gum naval stores industry, and over half of the gum is produced and 90 per cent or more is processed by the improved methods (Fig. 2).

Research Objectives

Vigorous research programs by other branches of the naval stores industry and by the chemical and petroleum industry have resulted in strong competition with gum naval stores for many older uses. Hence, a strong scientific research program directed toward improving gum naval stores products as well as finding new uses for them is essential if the industry is to survive. Such a research program has two equally important objectives: 1) to learn as much as possible about the chemical properties of pine gum and derived products; and 2) to find how these properties can best be used to provide more profitable markets for pine gum chemicals.

Research aimed at the first objective is called fundamental and includes determination of the exact chemical composition of pine gum, turpentine, and rosin, development of methods for separating individual chemical compounds from these mixtures, and studies of the chemical reactions of both the raw materials and pure compounds obtained from them. Just as the architect must know the properties of various types of wood in order to use them most effectively, so the chemist must know the properties of the various chemicals in order to make useful new products from them.

Research aimed at the second objective is technological in nature and includes evaluation for new uses or testing the chemicals to improve their position in existing uses. Modification of these chemicals to make them suitable for specific uses, and development of methods for producing them at a price competitive with similar products from other sources is of prime importance.

Various industrial groups have active research programs which are making important contributions in the field of pine gum chemistry. However, any discussion of advances made by these groups would be incomplete because many of their results are not published. Hence, the recent advances in pine gum chemistry described here will be limited to those made by the Naval Stores Research Section at Olustee, Fla.

Composition of Gum Turpentine

Increasing use of turpentine as a starting material for industrial chemical synthesis has emphasized the importance of knowing exactly what is present in typical commercial turpentines and has pointed to the need of

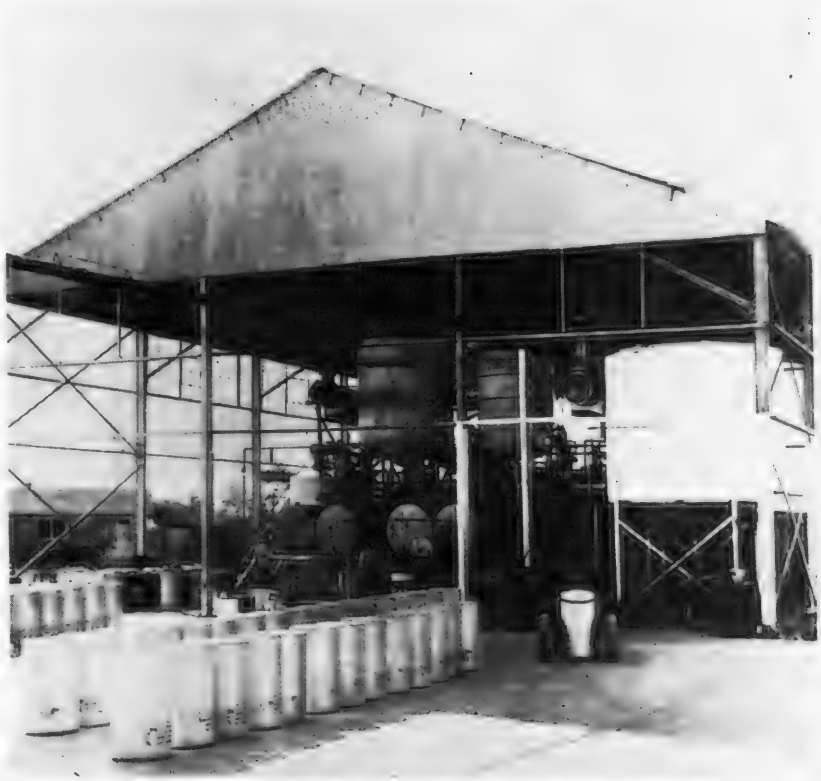


Fig. 2.—Modern processing plant for the cleaning and distillation of pine gum by the "Olustee Method".

analyses of individual samples for major components on a routine basis.

Turpentine consists chiefly of about a half-dozen hydrocarbons called terpenes, which are made up of ten carbon atoms and sixteen hydrogen atoms. In domestic turpentines, α- and β-pinene predominate (and account for approximately 90 per cent of the total components). Differences in the arrangement of the atoms in the terpene molecules cause considerable differences in their chemical and physical properties. Depending on the source of the turpentine, small quantities of other terpenes are frequently present in varying amounts. In addition to these hydrocarbons, turpentine also contains partially-oxidized compounds esters, aldehydes, alcohols, and ketones.

Variations in treatment of the raw gum and of the turpentine itself may cause variations in its composition. Under certain conditions, some of the components of turpentine can isomerize or change over into other compounds with the same elementary chemical composition but different structure. Exposure to air can cause partial oxidation of several of the components.

A typical commercial sample of turpentine (90 per cent slash, 10 per cent longleaf gum) was found to contain approximately 56 per cent *alpha*-pinene, 32 per cent *beta*-pinene, 2.4 per cent *beta*-phellandrene, 1 per cent camphene, and smaller amounts of *alpha*-phellandrene, limonene, myrcene, and terpinolene. Thirty-eight commercial samples examined had compositions of 55–67 per cent α-pinene (av. 61) and 34–26 per cent β-pinene (av. 30). Pure longleaf turpentine contains more α- and β-pinene than slash turpentine, and has little or no α-phellandrene (5).[2]

Research Tools

In determining the composition, the variation in boiling temperatures of these terpenes was used to separate them by fractional distillation by means of newly designed and more efficient fractionation columns. Differences in optical properties were utilized in their detection and identification by means of:

1. A polarimeter, which measures differences in ability to rotate plane-polarized light;
2. A refractometer, which measures the amount a light ray is bent while passing through a liquid;
3. Infrared and ultraviolet spectrophotometry, wherein complex instruments indicate or record the variations in absorption of ultraviolet or infrared radiation being passed through the liquid (Fig. 3).

[2] Figures in parentheses refer to Literature Cited.

Fig. 3.—Determining the properties of turpentine and rosin with an infrared spectrophotometer.

Infrared spectrophotometry is a particularly valuable tool, because the recorded, absorption spectrum of a given compound is comparable to a person's fingerprints—it is not exactly like that of any other compound. Its value to a chemist may be even greater than the value of a set of fingerprints to a law enforcement officer, because from it the chemist can determine the extent and nature of an impurity. Even more important, one can get a fairly accurate idea of the structure and properties of an unknown compound. It was the use of this tool which enabled our chemists to identify α- and β-phellandrene, camphene, and myrecene, none of which had previously been observed in commercial gum turpentine, and to determine the α- and β-pinene content of turpentine rapidly on a routine basis.

Composition of Rosin and Pine Gum

Rosin, too, is a complex mixture. It consists mainly of a group of at least eight tricyclic organic acids. These are all so similar in structure and behavior that their complete separation has defied all chemical and physical processes tested. About one-tenth of a typical rosin is composed of neutral compounds. In spite of much research, data on rosin composition is incomplete, and some of the older published data is misleading or incomplete.

Some progress, however, has been made toward separating the rosin acids by precipitation of their amine salts. Levopimaric, neoabietic, and *l*-abietic acids (11, 15, 16) have been isolated by this method. Complete success awaits the discovery of a specific amine for each acid.

The use of partition chromatography has also been quite successful for analysis (Fig. 4). Techniques have been developed which have resulted in the separation of the acids into the groups: 1) palustric, 2) levopimaric, *l*- abietic, dextropimaric, and isodextropimaric, 3) neoabietic, 4) dehydroabietic, 5) highly polar acids, possibly four non-charcterized acids[2]. Further investigation may permit other individual acids to be isolated. In the meantime, ultraviolet spectral analyses of these groups have made it possible to estimate the percentages of most of the individual acids present in the gum or rosin.

The acids in rosin are not the same as those found in the oleoresin of its origin. Isomerization during processing is quite extensive because of the high temperatures and the acidic environment (1, 15). Levopimaric acid, which may comprise nearly one-third of the acid content of the gum, is completely absent in rosin. A considerable portion of this acid should remain in the rosin if the turpentine were distilled at reduced pressure or after neutralization of the rosin acids. Special rosins containing some of this acid have been prepared in this manner (17) and the presence of small quantities of levopimaric acid in such rosin is expected to impart better paper-sizing qualities.

Fig. 4.—Rosin acids can be separated from a solution of pure rosin by partition chromatography.

The composition of the acidic portion of pine gum is approximately: 22–30 per cent levopimaric, 10 per cent *l*-abietic, 15 per cent neoabietic, 11 per cent palustric, 5 per cent dehydroabietic, 8 per cent dextropimaric, 8 per cent isodextropimaric, 13-2 per cent non-characterized (2).

A typical composition of the acidic portion of gum rosin is: 20 per cent *l*-abietic, 19 per cent neoabietic, 19 per cent palustric, 5 per cent dehydroabietic, 8 per cent dextropimaric, 3 per cent isodextropimaric, 21 per cent uncharacterized (2).

The most recent rosin acid to be isolated and characterized is palustric acid, first found in oleoresin from *Pinus palustris* (longleaf pine). As indicated, it is one of the most abundant acids in gum rosin and makes an important contribution to the unique properties of this rosin. It is one of the isomerization products of levopimaric acid (15).

Of the neutral portion, two aldehydes, dextropimarinal and isodextropimarinal have been isolated and identified (22, 23): Two alcohols have also been isolated. One of these, elliottinol from *Pinus elliotti* (slash pine) has been partially characterized (22, 24).

Hence, outstanding progress has been made in the last few years in determining the composition of pine gum, turpentine, and rosin. Much additional fundamental research will be required to fully explore the chemical reactions of all the individual components.

New Products from Turpentine

Of the products from turpentine, pinic and homopinic acid esters have excellent qualities both as plasticizers, (3, 18) and as lubricants for aircraft jet engines (21). Polymeric amides of these acids are the same type compounds as some of the modern synthetic fibers. It is possible that a very satisfactory synthetic fiber could be made from either acid.

Considerable research has been directed toward lowering the cost of these acids. Both are derived from pinonic acid, which is made by oxidation of alpha-pinene. The classical method for this oxidation requires the use of potassium permangenate. This is an excellent process for laboratory use but would be too costly for commercial production. Therefore other means of oxidizing *alpha*-pinene are still being sought. Ozonization fol-

low[illegible] by hydrolysis under oxidizing conditions has shown promise. Yields are only about 50 per cent, however, and optimum conditions must be found for the reactions involved (7, 12) before commercial production can be expected.

Oxidation has also been accomplished by bubbling air or commercial oxygen through heated pinene in the presence of various catalysts (20). Although this has not yet produced pinic acid in appreciable yields, some of the oxidation products may find other uses. One of these products, *alpha*-pinene epoxide, may find use in the field of epoxy resin plastics. Commercial production of this compound by another process has been announced recently.

Hydrogenation of pinene, followed by air oxidation, results in the production of pinane hydroperoxide (8, 9). A slightly more complicated series of reactions leads to *para*-menthane hydroperoxide. These compounds, the subject of recent patents (4, 5), have been developed commercially as catalysts in the manufacture of synthetic rubber and other polymers. In fact, nearly all the present production of synethetic rubber for automobile tires involves the use of one of these peroxides.

Isoprene, one of the building blocks for making synthetic rubber, may also be made from turpentine. Although isoprene from petroleum is less expensive, turpentine does provide an alternate source for this important item on the list of strategic materials.

New Products from Rosin

Progress has also been made in using the fundamental information already available to develop new or improved useful products, several of which are now in commercial production.

Among the more recent products from rosin, which have considerable commercial possibilities, are the esters of the condensation products of rosin with fumaric acid. These generally have higher melting points than corresponding esters from maleic anhydride modified rosin, a desirable property for many uses (10). Varnishes made from these esters have shown excellent qualities.

A somewhat similar product, maleopimaric acid, is made by reacting maleic anhydride with 1-pimaric acid (13). This compound, now being made commercially, is unique in that it is the only pine gum chemical produced directly from the gum without prior conversion to turpentine and rosin. The product is useful in printing inks, resins and photographic chemicals.

Metal resinates from rosins which have been modified with formaldehyde are superior in most respects to resinates made from ordinary unmodified rosin (25, 26). Production of these products is covered by widely licensed government patents. Very interesting new varnish resins have also been prepared from the methylolated rosin (19).

Conclusions

In recent years much progress has been made in clarifying the composition of pine gum, turpentine and rosin, by using newly developed analytical methods. Techniques have also been developed for isolating some of the resin acids in pure form on a preparative scale. Research along these lines is still in progress and its goal will not be accomplished until it is possible to make complete analyses of pine gum on a fairly routine basis and separate all the resin acids in sufficient quantities for use in subsequent investigations.

While many new chemicals have been prepared from pine gum, turpentine and rosin, some of them on a commercial scale, increasing emphasis is being placed on studying new chemical reactions of individual terpenes, resin acids, and commercial mixtures, as well as technological research on the products of these reactions.

Literature Cited

1. Baldwin, D. E., V. M. Loeblich, and R. V. Lawrence. 1956. Acid isomerization of levopimaric acid. J. Am. Chem. Soc. 78: 2015–17.
2. Baldwin, D. E., V. M. Loeblich, and R. V. Lawrence. 1957. The acidic composition of oleoresins and rosins. Presented at the Spring Meeting ACS, Miami, Fla.
3. *Conye, R. F. and E. A. Yehle. 1955. Ind. Eng. Chem. 47: 853–5. Plasticization of polyvinyl chloride with alkyl esters of pinic acid.
4. Fisher, G. S. and L. A. Goldblatt. 1956. Peroxides of saturated cyclic terpenes and method of producing same. U. S. Patent 2,735,870.
5. Fisher G. S. and L. A. Goldblatt. 1956. Polymerizations initiated by saturated cyclic terpene peroxides. U. S. Patent 2,775,578.
6. Fisher, G. S., R. L. Kenney, N. C. McConnell, and N. M. Joye. 1957. The hydrocarbon composition of gum turpentine. Presented at the Spring Meeting ACS, Miami.
7. Fisher, G. S. and J. S. Stinson. 1955. Pinonic acid. Preparation by ozonolysis of alpha-pinene. Ind. Eng. Chem., 47: 1569–72.
8. Fisher, G. S., J. S. Stinson, and L. A. Goldblatt. 1953. Peroxides from turpentine. II. Pinane hydroperoxide. J. Am. Chem. Soc. 75: 3675–78.
9. Fisher G. S., J. S. Stinson, R. N. Moore, and L. A. Goldblatt. 1955. Peroxides from turpentine. Production of technical grade pinane hydroperoxide. Ind. Eng. Chem. 47: 1368–73.
10. Halbrook, N. J. and R. V. Lawrence. 1957. Fumaric modified rosin. Presented at the Spring Meeting ACS, Miami.
11. *Harris, G. C. and T. F. Sanderson. 1948. Resin acids. I. An improved method of isolation of resin acids; The isolation of a new abietic-type acid, neoabietic acid. J. Am. Chem. Soc. 70: 334–39.
12. Holloway, F., H. J. Anderson and W. Rodin. 1955. Ozonolysis of alpha-pinene. Ind. Eng. Chem., 47: 2111.
13. Lawrence, R. V. and O. S. Eckhardt. 1953. Addition compounds of rosin and maleic anhydride and their production. U. S. Patent 2,628,226.
14. Loeblich, V. M., D. E. Baldwin, and R. V. Lawrence. 1955. The isloation of a new resin acid from gum rosin—palustric acid. J. Am. Chem. Soc., 77: 2823–25.
15. Loeblich, V. M., D. E. Baldwin, R. T. O'Connor, and R. V. Lawrence. 1955. Thermal isomerization of levopimaric acid. J. Am. Chem. Soc. 77: 6311–13
16. Loeblich, V. M. and R. V. Lawrence. 1956. An improved procedure for the isolation of neoabietic acid from pine oleoresin and rosin. J. Org. Chem. 21: 610–11.
17. Loeblich, V. M. and R. V. Lawrence. 1957. Inhibition of resin acid isomerization. Presented at the Spring Meeting, ACS, Miami.
18. Loeblich, V. M., F. C. Magne, and R. R. Mod. 1955. Terpene-derived plasicizers. Ind. Eng. Chem. 47: 855–8.
19. Minor, J. C. and R. V. Lawrence. 1957. Esterification of methylolated rosin. Presented at the Spring Meeting ACS, Miami.
20. Moore, R. N., C. Golumbic and G. S. Fisher. 1956. Autoxidation of alpha-pinene. J. Am. Chem. Soc. 78: 1173–76.
21. *Murphy, C. M., J. G. O'Rear, and W. A. Zisman. 1953. Pinic acid diesters. Ind. Eng. Chem., 45: 119.
22. Roberts, E. McC., N. M. Joye and R. V. Lawrence. 1957. A survey of the non-acidic components of commercial gum rosin. Presented at the Spring Meeting ACS, Miami.
23. Roberts, E. McC. and R. V. Lawrence. 1956. The occurrence of dextropimarinal and isodextropimarinal in commercial gum rosin. J. Am. Chem. Soc. 78: 4087–89.
24. Roberts, E. McC. and R. V. Lawrence. 1957. The isolation and partial characterization of elliotinol, a new resin alcohol. Presented at the Spring Meeting ACS, Miami.
25. St. Clair, W. E., J. C. Minor and R. V. Lawrence. 1953. Fused metal resinates from aldehyde-modified rosin. Ind. Eng. Chem. 46: 1973–76.
26. *Spurlin, H. M. 1946. Aluminum isopropoxide diresinate. U. S. Patent 2,403,767. Aluminum dialkoxide mono resinates. U. S. Patent 2,404,255.

* Research by chemists not associated with the Naval Stores Research Section, Naval Stores Station, Olustee, Fla.

Discussion

Conrad Schuerch (State University of N. Y. College of Forestry): Would you please describe the chromatographic method of analysis you used?

Mr. Patton: This is a very tricky determination. It involves the use of a column of silicic acid impregnated with furfuryl alcohol and 2 amino pyridine, the eluting solvent used is isooctane.

Moisture Blistering of Paints on Wood [1,2]

J. J. G. VEER

Tests show that blistering will result without a temperature gradient through a painted panel if it is continuously wet from the back. For water vapor to cause blistering, the temperature difference must be sufficient to cause condensation at the paint-film interface.

Introduction

THE FORMATION OF BLISTERS in exterior house paint was studied at the U. S. Forest Products Laboratory as far back as 1927, and by many other investigators since that time. However, it has not been possible yet to explain completely the mechanisms of moisture blistering. Dunn (3) has suggested that osmosis and osmotic pressure may be involved, whereas Babbitt (1) suggested a mechanism similar to osmosis by which moisture present in the wood can give rise to the pressure required to separate the paint film from its substrate. Browne (2) attributes the formation of blisters to the pressure of a fluid beneath the coating. Hopkins and Smart (4) do not favor the osmosis theory, but rather attribute the formation of blisters to an increase in volume of the water trapped between the wood and the paint film.

It appears that moisture blistering does not conform to a single mechanism. Due to the porous and hygroscopic nature of wood, a paint film blisters on such substrate by mechanisms that are not possible on nonporous substrates, such as glass or metal. Mechanisms that cause blistering on metal (osmotic and electroendosmotic blistering) (5) could produce the same effect on wood, if conditions are suitable, but their role is secondary in most cases.

It is generally agreed that moisture accumulated in the wood is in some way responsible for blistering. One point seems to be the subject of controversy, however, and that is the role of temperature. Hopkins and Smart (4) state that "no matter how wet the back of the siding, blistering does not occur unless there is a temperature differential". They have failed to obtain blistering on panels constantly wetted in the back with water but not submitted to a temperature gradient. On the other hand, Kuzmask and Sereda (6) report that blistering can be developed on painted panels immersed in water maintained at constant temperature.

From the above, it can be seen that there is disagreement on some of the conditions generally conducive to moisture blistering. A series of tests was made at the Ottawa Laboratory to determine whether a temperature gradient is necessary to induce the formation of blisters when the back of a painted panel is exposed to free water and to water vapor. This paper presents the results of these tests and of other preliminary tests carried out to determine the effect of thickness of the panels and of the wood species on the time required to develop blistering.

Apparatus and Materials

The apparatus used to study the different variables that have an effect on the blistering of paint consisted of a cabinet divided into two compartments. (Fig. 1). The cross-section of the cabinet was 23 by 28 inches. The partitions were sheets of plexiglass in which four 4- by 3-inch openings ("windows") were made. Test panels (5¼ by 4½ by $\frac{1}{16}$ inch) were clamped to these openings, and rubber gaskets were used to secure a tight fit (Fig. 2). Each compartment had a heating coil, a tray containing saturated salt solutions or water, and a fan to keep the air in constant circulation. Thus the conditions of moisture and temperature could be controlled and varied at will on both faces of the panels under investigation.

Paints tested for their resistance to blistering were ground at the Ottawa Laboratory. Their composition was as follows:

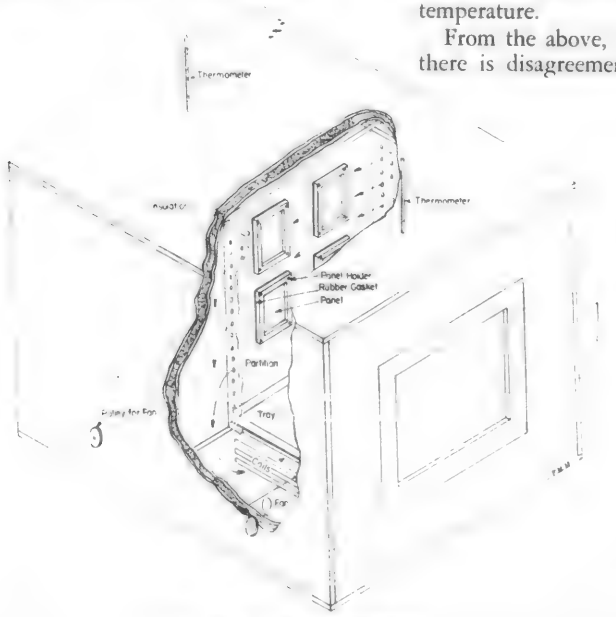


Fig. 1.—Blistering apparatus.

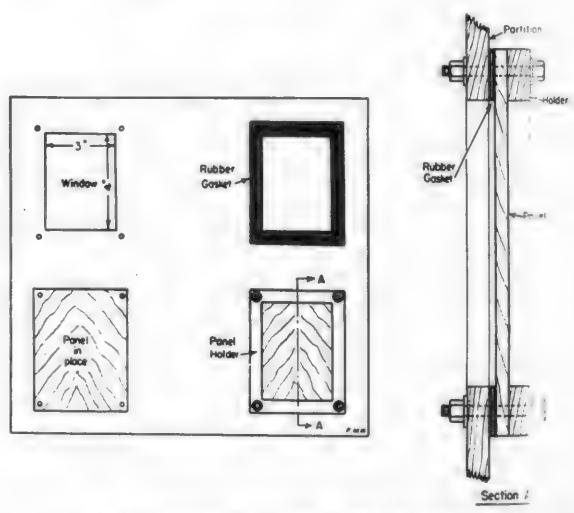


Fig. 2.—Details of partition and panel assembly.

[1] Presented at the Fifth Annual Meeting of the Eastern Canadian Section, FPRS, March 7-8, 1957, at the Queen's Hotel, Montreal, Quebec.

[2] A contribution from the Ottawa Laboratory, Forest Products Laboratories of Canada, a Division of the Forestry Branch, Department of Northern Affairs and National Resources.

Paint A —Carbonate white lead and zinc oxide, in boiled linseed oil,

Paint AA—Carbonate white lead, zinc oxide, and titanium dioxide, in boiled linseed oil, and

Paint B —Titanium dioxide in epoxy resin.

All panels were given two coats of paint and allowed to dry for a week before they were tested.

Experiments and Results

To determine whether water alone can produce blistering, painted panels were kept fully immersed in water maintained at constant temperature. Paints A, AA and 4 other linseed-oil paints blistered under these conditions, but paint B did not. Paint A blistered on panels floating on water, either with the painted face up or down (Fig. 3). Kuzmask and Sereda (6) obtained similar results.

Fig. 3.—Blistering of paint on wood immersed in water (left) and with a column of water at the back (right).

In a second series of tests, the painted panel (1/16 inch thick) was fastened to a Payne cup filled with a definite amount of water, and the cup was turned upside down to have a column of water or a hydrostatic pressure on the back of the painted panel. The assembly was kept in a room at constant temperature. Paint A, which was the only paint tested, blistered rapidly under a column of water of 4 cm. (Fig. 3). Hopkins and Smart (4) report that under similar conditions there was no sign of blistering during a period of 13 days. When the water was replaced by ethyl alcohol, blistering still occurred, but to a lesser extent. In a third series, the Payne cup was not inverted but was heated to 100° C. Paint A blistered in 20 minutes, whereas paint B did not blister after a period of 7 hours, at which time the test was discontinued because all water in the cup had evaporated.

The results of these first two series of experiments, in which the back of the panel was always wetted by water, show that water alone can be sufficient to produce blistering. The difference in behavior of paints A, AA and B should be attributed to the different properties of their films.

To determine whether a vapor-pressure differential can induce the formation of moisture blisters, the back and coated faces of test panels prepared with paint A were exposed to water vapor of various pressures in the blistering apparatus. The temperature was kept the same on both sides of the panel. The relative humidity was kept higher at the back than at the coated face to produce a vapor-pressure differential to promote the diffusion of moisture from the back to the paint-film interface. The relative humidities at the coated face were varied so as to increase the vapor-pressure differential from test to test, as shown in Table I.

Paint A did not blister on red pine panels (¼ inch thick) under vapor-pressure differentials of 6, 9, 28 and 36 mm. of mercury after two weeks of exposure. The substrate did absorb moisture during that period, but its final moisture content was still below the fiber saturation point. These results show that water vapor alone in the wood did not cause paint blistering. The vapor-pressure differential that causes the moisture movement from one side (back) to the other does not lead to the formation of blisters, provided that the front and the back of the panel are at the same temperature.

The next step in the investigation was to determine whether, in the absence of free water, a temperature gradient is an essential condition to produce blistering on wood exposed to a humid atmosphere. A series of tests was undertaken to find out under what conditions of water vapor-pressure and at which temperature gradient blistering will take place.

While the temperature gradient was kept constant, the relative humidity was varied at both the back and the coated face, always in such a way as to keep the moisture movement from the back to the paint-film interface.

Results of these tests (Table 2) show that, with 100, 95, or 80 per cent relative humidity at the back, and from 10 to 100 per cent at the coated face, blistering always developed. Blistering did not develop with 62 per cent R. H. at the back and 12 per cent R. H. at the coated face, even with a temperature gradient of 6° C.

In a subsequent experiment, the relative humidity was kept identical on both sides (100 per cent) but temperatures were different. Results of these tests (Table 3) show that, as in the preceding series of tests, blistering will not always occur, even with a temperature gradient; paint AA did blister in some cases and not in others.

Although the data presented in Tables 2 and 3 are from different test

Table 1.—EFFECT OF A VAPOR-PRESSURE DIFFERENTIAL ON BLISTERING OF PAINT A

Uncoated side		Coated side		Difference* in		
T. (°C.)	Sol.	T. (°C.)	Sol.	R.H. (%)	V.P. (mm.)	Blistering
[illegible]	H_2O	34	KCL(Sat.)	16	6	Nil
[illegible]	H_2O	34	NH_4CL(Sat.)	23	9	Nil
[illegible]	H_2O	34	$CaCL_2$(Sat.)	70	28	Nil
[illegible]	H_2O	34	$ZnCL_2$(Sat.)	90	36	Nil

*Approximate figures.

Table 2.—VARIATIONS OF RELATIVE HUMIDITIES AND THEIR EFFECT ON BLISTERING OF PAINT AA

Uncoated side		Coated side		Difference* in		Blistering
T. (°C.)	R.H. (%)	T. (°C.)	R.H. (%)	R.H. (%)	V.P. (mm.)	
43	100	38	100	0	15	Yes
43	100	38	96	4	17	Yes
43	100	38	62	38	34	Yes
43	100	38	43	57	43	Yes
43	100	38	30	70	50	Yes
43	100	38	10	90	60	Yes
46	95	40	10	85	66	Yes
46	80	40	42	38	38	Yes
46	80	40	30	50	45	Yes
46	80	40	19	61	50	Yes
46	80	40	10	70	56	Yes
46	62	40	12	50	40	No

*Approximate figures.

Table 3.—EFFECT OF VAPOR-PRESSURE AND TEMPERATURE DIFFERENTIALS ON BLISTERING OF PAINT AA

Uncoated side		Coated side		Difference in		Blistering
T. (°C.)	R.H. (%)	T. (°C.)	R.H. (%)	V.P. (mm.)	T. (°C.)	
55	100	39	100	72	16	Yes
41	100	33	100	21	8	Yes
33.5	100	31.5	100	4	2	Yes
29	100	28	100	2	1	Nil after 14 days

conditions, the results obtained indicate that, as the relative humidity at the back decreases, the temperature gradient must increase in order to produce blistering. Blistering was seen to develop at a 2° C. differential with 100 per cent R. H. at the back (Table 3), and at a 6° C. differential and 80 per cent R. H. (Table 2). Blistering did not develop, however, at a 6° C. differential and 62 per cent R. H. (Table 2). The minimum temperature differential required for moisture blistering appears to depend mainly on the relative humidity prevailing at the back.

It appeared that this minimum temperature differential might be that which would occur between the temperature at the back and its corresponding dew-point. A study of conditions close to the dew-point was therefore undertaken. This investigation provided for conditions of temperatures and relative humidities at the back as follows: a) 30° C. and 92 per cent R.H., b) 30° C. and 84.5 per cent R. H., and c) 30° C. and 63.3 per cent R. H. This variation in relative humidity was obtained with saturated salt solutions of $NH_4H_2PO_4$, KCL and $NaNO_2$ (7). The dew-points of these atmospheres are respectively: a) 28.6° C., b) 27.5° C., c) 22.1° C. (8). Two series of tests were carried out for each condition mentioned above: in the first one, the temperature at the coated face was kept below the dew-point. In the second series, the temperature at the coated face was above the dew-point.

Results of these tests showed that blisters formed only when the temperature of the coated face was below the dew-point, and that no blistering occurred above the dew-point after two weeks of exposure. There was water condensation behind the paint film only on samples tested below the dew-point. Free water in the wood is necessary to initiate this mechanism of blistering; water vapor is not sufficent. This explains why there was blistering in some cases and none in others in previous tests. In some cases the temperature was sufficiently low, and not low enough in others, to permit water-vapor condensation at the paint-film interface. This observation will be checked by further investigations.

In addition to these tests in which conditions conducive or not conducive to blistering were studied, other tests were carried out to investigate the effect of thickness of panel and the influence of wood species on blistering. It was observed that the blistering time increases with the thickness of the panels, whereas the severity of blistering decreases. Thus, for a 1/16 inch, 5/16-inch and ½-inch white pine panels, paint AA took respectively 6, 21 and 30 hours to blister. As for the effect of wood species, blistering developed more rapidly and to a greater extent on certain wood species than on others. On eastern cedar, blisters developed between 8 and 22 hours, on spruce between 32 and 46 hours, and on aspen between 106 to 120 hours. Blistering was also much more severe on cedar than on aspen.

Blisters developed in the paint film are not permanent, that is, they shrink back into place if the conditions that caused them are changed or when the substrate dries out. Blisters keep their form, however, if the paint film is stripped from the substrate.

The presence of free water at the paint-film interface has a more drastic effect on the adhesion of the paint film to its substrate than does water vapor alone. Thus it is possible to strip the paint film very easily when free water is present in the wood (Fig. 4), whereas it is impossible when water vapor alone is present. It would seem, therefore, that one of the functions of the water in the wood is to decrease the efficiency of the bond between the film and the substrate, and that once this bond is weakened, high pressure is not necessary to produce blisters. This is supported by the finding of Kuzmask and Sereda (6) that the pressure of nitrogen required to produce blisters was in one case 250 psi, and that when nitrogen was replaced by water, the pressure was 15 psi. This is an aspect which requires further investigation, however.

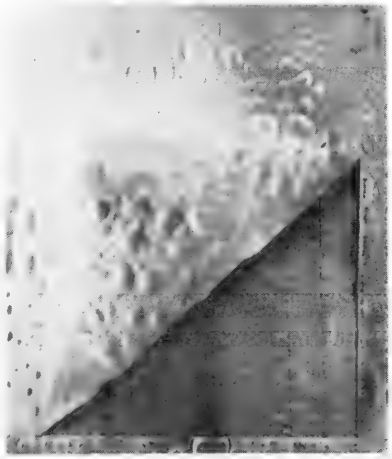


Fig. 4.—Paint film is easily removed. Blister marks can be seen on freshly stripped wood surface.

Conclusions

Results of the tests show that, if water continuously wets the back of a painted panel, blistering will develop without a temperature gradient. If there is only moisture or water vapor, however, the difference in temperature between the back and the coated face must be sufficiently great to permit water-vapor condensation at the paint-film interface to induce blistering; otherwise blistering will not take place. This fact indicates that, to cause blistering, the temperature of the coated face need only be sufficient to allow condensation of free water behind the paint film.

Research data so far obtained are insufficient as a basis for positive findings. Additional work is now in progress at the Ottawa Laboratory, Forest Products Laboratories of Canada. This work includes determination of the pressure required to produce blisters on wood at different moisture contents, the effect of paint variables such as pigments, vehicles, and age of paint film, and the relation between the water permeability of a paint film and its degree of blistering. When work now in progress or in the planning stage has been completed, it is hoped that the mechanism of blistering of paint coatings will be better understood.

References

1. Babbitt, J. D. 1954 Osmotic pressure, semi-permeable membranes and the blistering of paint. Canadian Journal of Technology 32:49–54.
2. Browne, F. L. 1953. Some causes of blistering and peeling of paint on house siding. U. S. Forest Products Laboratory Report No. 6.
3. Dunn, E. J., Jr. 1952. Water permeability of paint materials for wall construction. Official Digest 329:765–77.
4. Hopkins, C. Y., and B. C. Smart. 1953. Experimental study of blistering of paints on wood. Chemistry in Canada 5(9):35–40.
5. Kittelberger, W. W., and A. C. Elm. 1946–47. Water immersion testing of metal protective paints. Ind. and Eng. Chem. 38:695–9, 39:876–81.
6. Kuzmask, J. M., and P. J. Sereda. 1955. The blistering of paint in presence of water. Canadian Journal of Technology 33:67–76.
7. Wink, W. S., and G. Sears. 1950. Instrumentation Studies LVII. Equilibrium relative humidities above saturated salt solutions at various temperatures. TAPPI 33(9):96A–9A.
8. Handbook of Chemistry and Physics 1942. 26th Edition.

The Dielectric Properties of Resin Glues for Wood[1,2]

DONALD G. MILLER and T. J. S. COLE
Ottawa Laboratory, Forest Products Laboratories of Canada

Results of measurements show that the conductivity of a given sample of resin glue is sensistive to temperature and to its formulation, but is independent of frequency over the range of frequencies normally used in dielectric heating for wood gluing.

Introduction

THE CURING OF MOST RESIN GLUES used in bonding wood can be accelerated greatly by raising their temperatures. If a high-frequency electric field is set up in the wood and in the glue lines, heat is generated throughout the glue lines due to their dielectric and ohmic losses. Two general classes of field distribution are used, one with the field parallel to the glue lines and the other with the field perpendicular to the glue lines. For applications where the electric field is parallel to the glue lines, the dielectric properties of the glue used are very important. Because of variations in these properties it has been found that certain glues require four to five times as much radio-frequency power to effect a cure as do others of the same type.

A study of the dielectric properties of a number of commercial resin glues has been made by Yavorsky[3] using a General Radio Type 916A Impedance Bridge. He gives a table of the conductivities and dielectric constants for these samples at an arbitrary mix age of one hour for frequencies of 4, 8, 12, and 16 megacycles, and also indicates the dependence of conductivity on the amount of catalyst added to the neutral resin.

The present study of some commercial resin glues was made with a General Radio Type 821–A Twin–T Impedance Measuring Circuit with attention to the corrections required because of the inductance of the sample holder. The dependence of dielectric constant and conductivity on age of mix, on frequency, on temperature, and on constitution was determined for catalyzed and uncatalyzed samples of urea, resorcinol, phenol-resorcinol, and melamine type commercial glues.

Equipment and Method of Measurement

The measuring equipment consisted of a General Radio Type 821–A Twin–T Impedance Measuring Circuit, and a General Radio Type 1330–A Bridge Oscillator. A Hallicrafter SC–77A Communications Receiver and, in certain instances, an LFE oscilloscope model 401 were used as detectors. The glue samples were placed in a coaxial-type sample holder, which plugged into the Twin–T circuit either directly or in series with a small moulded mica condenser (Fig. 1). The sample holder is shown completely assembled and also separated into its component parts in Fig. 2.

A single measurement of the admittance of the sample-filled holder allowed the determination of the dielectric properties of the sample once

Fig. 1.—Equipment used for measuring the dielectric properties of resin glues.

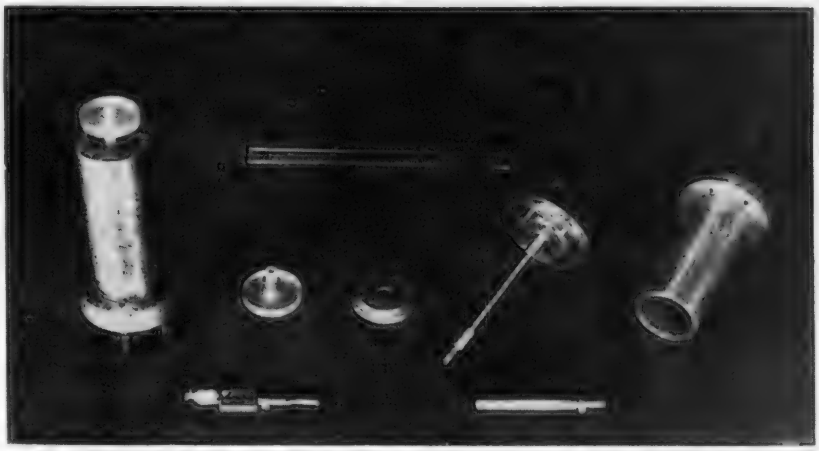


Fig. 2.—Sample holder used for measuring the dielectric properties of resin glues, shown assembled and disassembled. Series condenser is in the foreground.

[1] A contribution from the Forest Products Laboratories of Canada, a division of the Forestry Branch, Department of Northern Affairs and National Resources.

[2] Presented at Session I, Glues and Gluing, FPRS 11th National Meeting, June 23-28, 1957, in Buffalo, N. Y.

[3] Yavorsky, J. M. 1951. Research in electronic wood gluing. Proc. of FPRS, p. 285.

The Authors: Donald G. Miller received a B.Sc. degree in electrical engineering from Queen's University, Kingston, Ont. He is a specialist in dielectric heating and electronics at the Forest Products Laboratory, Ottawa.

T. J. S. Cole received a B.Sc. degree from the University of London, Eng., and a B.Sc. degree in physics from Carleton College, Ottawa. He is now on leave of absence from the Faculty of Carleton, studying for a doctorate degree at the University of Cambridge, Eng. He conducted work on this study while employed by the Ottawa Laboratory during the summers of 1954 and 1955.

the holder had been calibrated with a liquid sample of known dielectric properties. The construction, calibration, and advantages of this type of holder are discussed in "The Dielectric Properties of Resin Glues for Wood", Forest Products Laboratories of Canada, F.P.L. Technical Note No. 4, 1957. This publication contains, also, a full description of the methods of measurement and calculation used in the study.

Preparation of Samples

For the conductivity against time test, the glue samples were mixed according to the manufacturer's instructions, brought to room temperature, and allowed to stand 10 or 15 minutes until most of the bubbles of trapped air had escaped. The sample holder was filled and plugged in series with a condenser into the bridge circuit, which was then balanced periodically at a fixed frequency of 1, 3, or 10 mc (megacycles) up to the end of the pot life.

For the conductivity against frequency test, the samples were prepared as above and tested at frequencies of 0.55, 1, 2, 4, 8, 16, and 32 mc. Each sample in turn was carried through this range of frequencies as quickly as possible to reduce the effect of variation of conductivity with time. This was done by estimating beforehand for the given sample, the value of the series condenser required at each frequency to keep the conductance balance within the range of the conductance dial on the bridge circuit. Choosing condensers of the nearest values, the preliminary conditions of balance for each condenser were determined at the appropriate frequencies and drawn up in a table for easy reference. On switching to each successive frequency, the initial balance condition could be reset and the measurement made quickly and easily.

For the conductivity against temperature test, the sample holder and the samples of the uncatalyzed liquid resin were brought to just below the lowest temperature of measurement by placing them in a refrigerator. After the holder and samples were removed from the refrigerator, the sample was added to the holder and the combination was allowed to reach equilibrium as read on a thermometer inserted in the open holder. The thermometer was removed and the holder topped up with some of the sample that had been adjusted simultaneously to the same temperature. The holder was then plugged into the bridge circuit, the circuit was balanced at 3 mc and the readings were recorded.

After the contents were decanted, the holder was placed in a water bath kept at the next higher temperature required, the sample was raised to the same temperature, and the procedure was repeated as before. Because the steel sample holder had a fairly large mass and heat capacity, the equilibrium temperature did not change too rapidly during measurement except at the lowest and highest temperatures, where an attempt was made to correct temperature roughly for the rate of heating and cooling. This limited the upper temperature reached by this simple method to about 80° C.

The procedure was similar for catalyzed liquid resins, The catalyst was added and mixed in after the liquid resin had been cooled below the lowest temperature required. For powered resins, the water and powder were cooled to 0° C. before mixing, the procedure thereafter being the same. Because this simple process was rather time consuming, the catalyzed glues had usually reached the setting stage by the time readings up to 60° C. had been achieved. Variation of conductivity with time was thus superimposed on the variation with temperature.

For the conductivity against salt (sodium chloride) concentration test, the procedure was the same as in the conductivity against time test except that measurements were made only at 1 mc and at about 45, 60, and 75 minutes after the time of mixing. This was done to get a comparison of the conductivities at an arbitrary time of 60 minutes and to observe the variation with time at the various concentrations. The test was carried out with the salt added to the liquid resin before the catalyst and with the salt added after the catalyst.

Results of Measurements

Conductivity and Dielectric Constant against Time at 1, 3, and 10 mc: The dependence of conductivity on time for catalyzed samples is shown in Fig. 3 for ureas and Fig. 4 for resorcinols, phenol-resorcinols and melamine at a frequency of 1 mc and at room temperature. The graphs for 3 mc and for 10 mc are not shown because they are the same as the above except for differences due to the different ambient temperatures at the time of measurement.

There was only a slight decrease with time for a few samples of low conductivity where the dielectric constant could be reliably determined so no graphs of dependence of dielectric constant on time are shown.

In Fig. 3, the majority of the urea samples are seen to decrease in conductivity with time by about 10 per cent per hour or less during their working life. Two samples (UL_2 and UL_3) are seen to first decrease slightly and

Table 1.—CONDUCTIVITY AND DIELECTRIC CONSTANT OF UREA RESIN GLUES AT 1, 3 AND 10 MC AT AN ARBITRARY MIX AGE OF ONE HOUR

Adhesive	Mix ratio, parts per 100 parts resin by weight		Conductivity, micromhos per cm.(g) (Corrected to 25° C.)			Dielectric constant (k)						Dissipation factor, corrected values (g/k kω		
	Hardener	Water	1 mc	3 mc	10 mc	1 mc		3 mc		10 mc		1 mc	3 mc	10 mc
						*	†	*	†	*	†			
U.L. 1			36.5	44	80	54	54	55	55	45	45	1.2	0.48	0.32
	20		290	150	230	72	72	53	53	43	44	7	1.9	0.94
U.L. 2			105	125	138	37	37	67	67	55	56	5.5	1.1	0.44
	10		340	540	560	83	84	67	70	49	52	7	5.2	2.0
U.L. 3			71	107	141	72	72	60	60	49	50	1.8	1.1	0.51
	½		250	240	310	67	75	55	56	47	48	6.2	2.7	1.2
	1		630			75	78					14		
U.L. 4			30	44	66.5	54	54	50	50	42	42	1.0	0.53	0.28
	10		570	690	620	73	75	65	69	40	44	13	6.5	2.6
	20		990			81	89					20		
U. L. 5			225	§	281	34	34	§	§	50	50	13	§	1.0
	20	5	1550	1550	1550	120	130	61	70	50	65	21	14	1.1
U.P. 1		33	950	770	980	97	103	61	67	45	48	18	8.0	3.8
U.P. 2		48	1800	1700	2250	‡	‡	55	71	46	64	‡	14	5.6
U.P. 3		60	2800	2700	3100	130	170	80	110	37	62	30	15	8.5
U.P. 4		65	3100	3350	3500	‡	‡	29	63	20	68	‡	23	8.8

U.L.—liquid urea resins.
U.P.—powdered urea resins.
*—uncorrected values.
†—corrected values.
‡—excessively high values of k at 1 mc.
§—no value available due to error in measurement.
—15 parts of hardener.

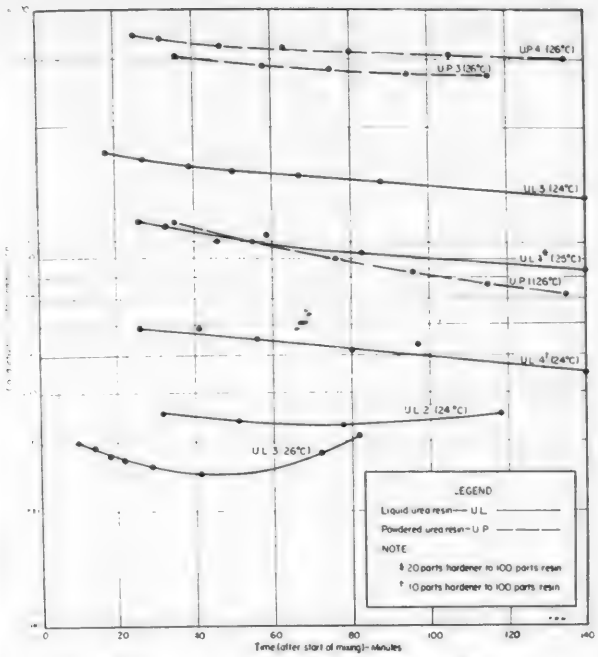


Fig. 3.—Conductivity v. time at 1 mc for urea glues.

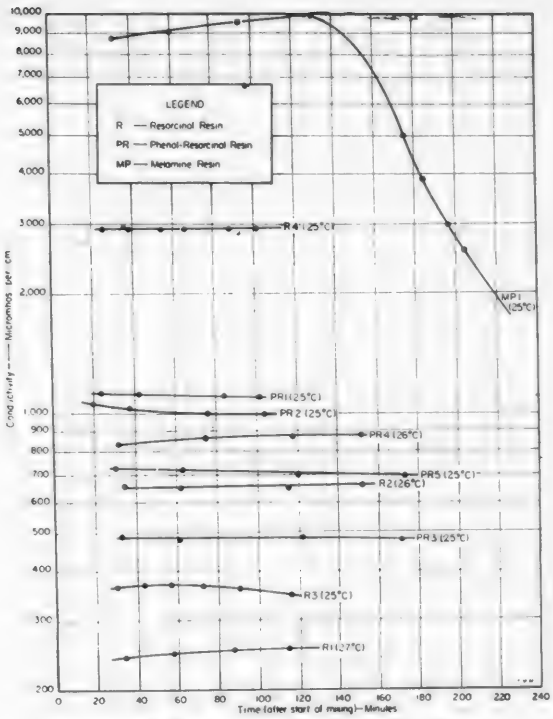


Fig. 4.—Conductivity v. time at 1 mc for resorcinol, phenol-resorcinol, and melamine resins.

then increase again. From the other measurements these were found to increase rapidly as they began to cure. This was not observed with the other samples in the range of working life covered.

In Fig. 4 all the resorcinol and phenol-resorcinol samples are seen to remain constant in conductivity with time. The one melamine sample tested increased slightly in conductivity with time until near the end of its working life when its conductivity decreased rapidly.

From the results at 1, 3, and 10 mc, Table 1 for ureas and Table 2 for resorcinols, phenol-resorcinols, and melamine have been drawn up to show the measured values of conductivity and dielectric constant at an arbitrary working life of one hour from the start of mixing. Also shown are the values of dielectric constant and dissipation factor when correction is made for the inductance of the sample holder. In these tables, the values of the conductivity have been brought to a common temperature reference of 25° C. by allowing a 3.5 per cent change in conductivity per degree centigrade change from the temperature at the actual time of measurement. Also shown in these tables are the conductivity and dielectric constant for the liquid resins with no catalyst added.

From these tables or from the graphs, the catalyzed samples can be seen to cover a wide range of conductivities from 200 microm hos/cm to

Table 2.—CONDUCTIVITY AND DIELECTRIC CONSTANT OF RESORCINOL, PHENOL-RESORCINOL, MELAMINE RESIN GLUES AT 1, 3, AND 10 MC AT AN ARBITRARY MIX AGE OF ONE HOUR

Adhesive	Mix ratio, parts per 100 parts resin by weight		Conductivity, micromhos per cm. (g) (Corrected to 25° C.)			Dielectric constant (k)						Dissipation factor, corrected values g/k $ko_{(\omega)}$		
						1 mc		3 mc		10 mc				
	Hardener	Water	1 mc	3 mc	10 mc	*	†	*	†	*	†	1 mc	3 mc	10 mc
R 1	25	--	240	215a	260	41	40	31a	31a	31	31	11	4.2	1.5
		--	29	33	54	25	25	21a	21a	18a	18	2.1	0.94	0.54
R 2	20	--	640	650	770	58	61	43	46	36	40	19	8.5	3.5
		--	1070	1030a	1010	46	53	36a	43a	41	47	36	14	3.9
R 3	20	--	370	360	380	45	46	40	41	30	31	14	5.4	2.2
		--	490	545	475	51	52	40	42	35	35	17	7.8	2.2
R 4	17	--	2900	2300	2800	§	§	‡	28	37	70	§	49	7.5
		--	3650	3060	4100	§	§	‡	35	11	82	§	55	9.2
PR 1	20	--	1080	1070a	1070	53	60	51a	59a	34	40	32	11	4.8
		--	1720	1750a	1810	27	46	26a	45a	24	44	67	19	7.4
PR 2	20	--	1060	950	905	53	60	50a	55a	36	41	30	10	4.0
		--	1620	1410a	1500	37	56	31a	47a	31	46	52	18	5.9
PR 3	20	--	480	505a	515a	41	43	37a	38a	31a	33a	20	8.0	2.8
		--	790	800a	800	41	45	41a	46a	41	43	32	10.5	3.4
PR 4	20	--	835	840a	895a	51	54	48a	53a	35a	40a	28	9.5	4.0
		--	1300	1280a	1270	40	53	46a	57a	38	53	44	13	4.3
PR 5	20	--	715	705a	720a	48	51	46a	49a	36a	39a	25	8.6	3.3
		--	1000	1010a	1000	45	52	40a	47a	42	49	35	15	3.7
M	10	40	9010	8850	7850a	---	---	---	---	---	---	---	---	---
		40	40a	46a	56a	33a	33a	37a	37a	35a	35	2.2	0.75	0.29

R—Resorcinol formaldehyde.
PR—Phenol-resorcinol formaldehyde.
M—Melamine formaldehyde.
a—Average of two or more values.

* Uncorrected values.
† —Corrected values.
‡—Susceptance and reactance of sample and cell were inductive.
§—Excessively high value of k at 1 m/c.

9000 micromhos/cm, with the largest group falling between 200 and 1000 micromhos/cm, the remainder from 1000 to 9000 micromhos/cm. In all cases, the catalyzed ureas are several times higher in conductivity than their respective uncatalyzed liquid resins. In all cases but one, the catalyzed resorcinols and phenol resorcinols are lower in conductivity by 30 to 40 per cent than their respective uncatalyzed liquid resins. The exception (Sample R1) has a conductivity when catalyzed that is eight times greater than that of the liquid resins. The catalyzed melamine has a conductivity about 200 times that of the uncatalyzed resin.

No definite dependence of conductivity on frequency can be seen in these tables due to the effect of the temperature variation from test to test. For highly ionized solutions such as most of these samples, conductivity should be independent of frequency as was confirmed by the results of a separate experiment (described in next section) to determine the dependency of conductivity on frequency.

The dielectric constants of the catalyzed urea samples, where measurable, are all quite similar to each other and to the dielectric constants of the uncatalyzed samples. The dielectric constants of the resorcinol and phenol-resorcinol groups (where measurable) are all quite similar also.

The dielectric constant of the melamine sample could not be determined because of its high conductivity. After correction for sample-holder inductance all these dielectric constants decrease slightly with frequency. The dependence of dielectric constant on frequency was also determined in a separate experiment. The following section describes the results.

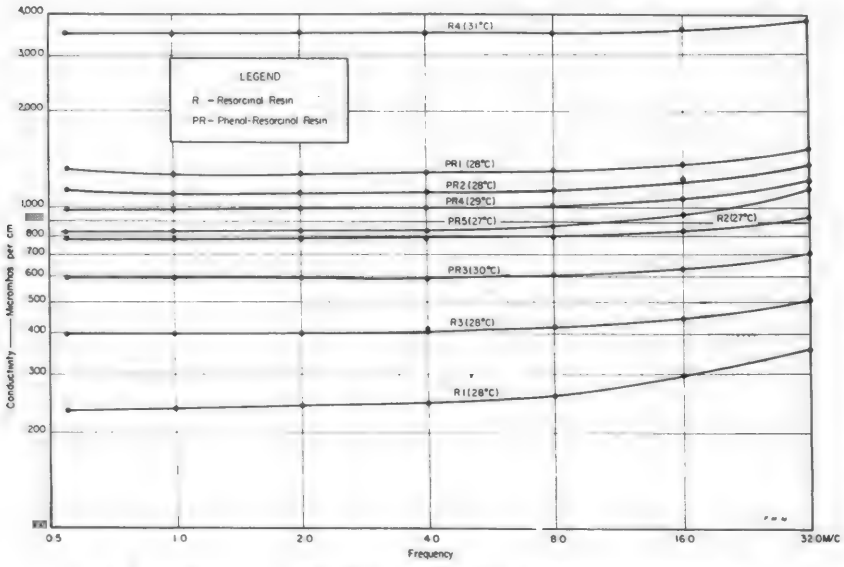


Fig. 5.—Conductivity v. frequency for resorcinol and phenol-resorcinol resins.

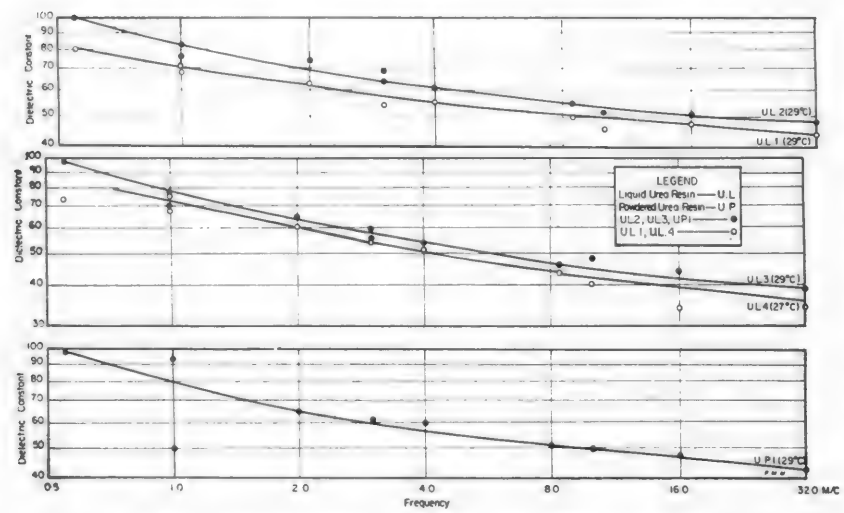


Fig. 6.—Dielectric constant v. frequency for catalyzed urea glues.

Conductivity and Dielectric Constant against Frequency at Room Temperature: It was pointed out in the previous section that the temperature of the sample under test varied from test to test due to the change in the ambient temperature, which ranged from 22° C. to 32° C. Results presented in a later section show that the conductivity varies about 3.5 per cent per degree centigrade at room temperature, so the extreme variation here is about 35 per cent. To avoid this effect, the conductivity of the sample was determined in one quick run at spot frequencies of 0.55, 1, 2, 4, 8, 16, and 32 mc. The dependence of conductivity on frequency is shown in Fig. 5 for the catalyzed resorcinols and phenol-resorcinols.

Despite the effort to carry out the test quickly to reduce the effect of decrease of conductivity with time present in the urea samples, the effect was still present and masked the results. It is difficult to correct for this because the rate of decrease depends on the ambient temperature at the time of the test. These results are not plotted, therefore, but showed evidence that on correction the conducivity would not change much with frequency over the range covered.

The dependence of dielectric constant (where measurable) on frequency is shown for the urea samples in Fig. 6 and for the resorcinol and phenol-resorcinol samples in Fig. 7. The points for one or more samples are grouped along the curve to which they most nearly fit. All the curves are similar in shape, but their values vary in magnitude, depending on the sample. The points at the 0.55 mc end are usually not reliable to better than 25 to 50 per cent depending on the conductivity of the sample. Otherwise the rest of the curve shows the dielectric constant decreasing as frequency increases.

Conductivity against Temperature at 3 mc: The variation of conductivity with temperature at a frequency of 3 mc is shown in Figs. 8 to 1

The results for the uncatalyzed resins are shown in Fig. 8 for the ureas and Fig. 9 for the resorcinols and phenol-resorcinols. In each graph, most of the curves have similar slopes although they have values of different magnitudes. The urea samples have curves of nearly constant slope, whereas the resorcinol and phenol-resorcinol samples have curves of slopes that decrease with increasing temperature. By extrapolation it is possible to predict what the conductivities will be near 100° C. Roughly, it appears that a change from 25° C. to 100° C.

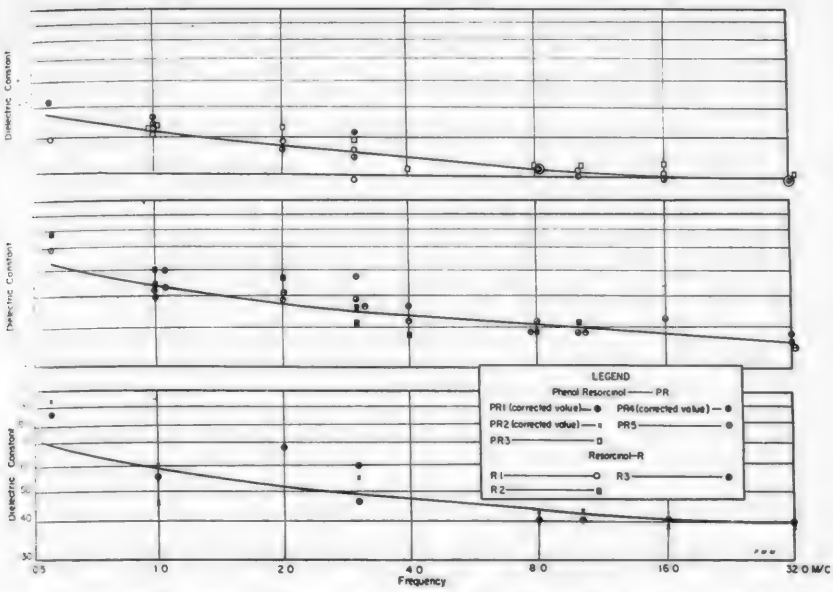


Fig. 7.—Dielectric constant v. frequency for catalyzed resorcinol and phenol-resorcinol glues.

would produce a six-fold to eight-fold increase in the conductivity of most uncatalyzed resins.

The results for the catalyzed resins are shown in Figs. 10 and 11. Fig. 10 is similar to the corresponding Fig. 8 for the uncatalyzed ureas, but the slopes of the curves fall off at the higher temperatures. This is because of the slowness of the method used, since the conducivity of the ureas decreases with time.

Fig. 11 for the catalyzed resorcinol and phenol-resorcinol resins is similar to Fig. 9 for the uncatalyzed resins up to the highest temperature reached, except for the case of sample R4, which increased suddenly in conductivity as its curing point was reached. From these results it might be presumed that, if a catalyzed glue temperature is raised to the region of 100° C. in a time that is short compared to the curing time at or near 100° C., its conductivity will, as in the case of the uncatalyzed glue, be increased some six- to eight-fold over its conductivity at 25° C. As curing progresses, the conductivity will then be modified in some way. The melamine sample was not tested.

Dielectric Constant against Temperature at 3 mc: The variation of the dielectric constant for both uncatalyzed and catalyzed samples is shown in Fig. 12 for temperatures from 0° C. up to 70° C. with correction for the sample-holder inductance. The values are not measurable in many cases, and in others no reliable correction can be applied. The uncatalyzed liquid ureas all show a similar form of curve, with a broad maximum around 30° C. to 50° C. The only uncatalyzed resorcinol with enough reliable values (sample R3) follows a similar curve, though the points for sample R1, which are believed to be reliable, do not reach a maximum in the range of temperature covered. Polar dielectrics should decrease in dielectric constant with increasing temperature, and above a certain temperature this seems to happen in the case of the ureas and resorcinol sample R3.

The dielectric constants range from about 50 to 70 for the uncatalyzed ureas at the center of this temperature range. Those for resorcinols and phenol-resorcinols lie roughly around 40 to 45, with sample R1 down at 21. These values seem reasonable because the ureas are suspended in water (k = 80) and vary slightly in the proportion of solids to water. Likewise,

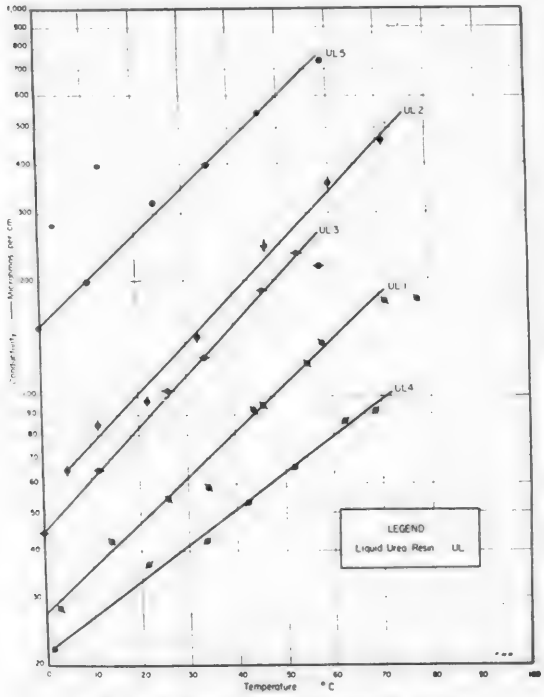


Fig. 8.—Conductivity v. temperature for urea resins (uncatalyzed) at 3 mc.

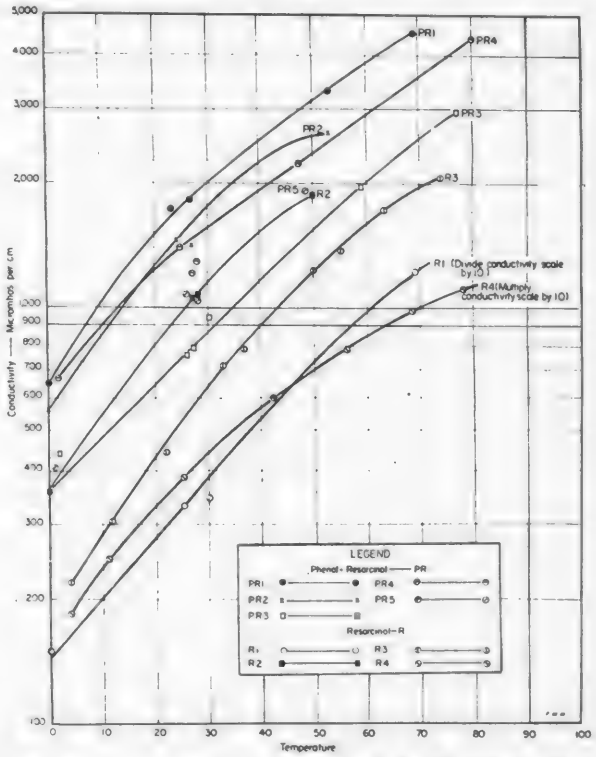


Fig. 9.—Conductivity v. temperature at 3 mc for resorcinol and phenol-resorcinol resins (uncatalyzed).

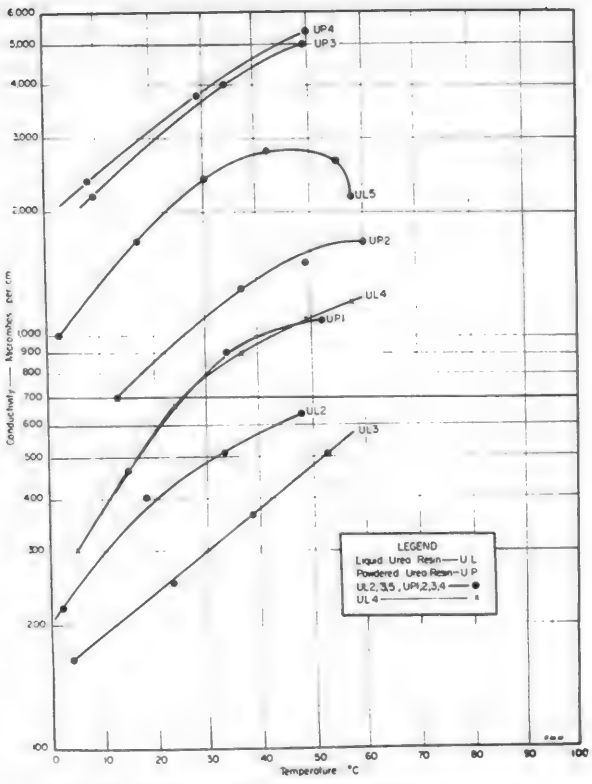


Fig. 10.—Conductivity v. temperature at 3 mc for urea resins (catalyzed).

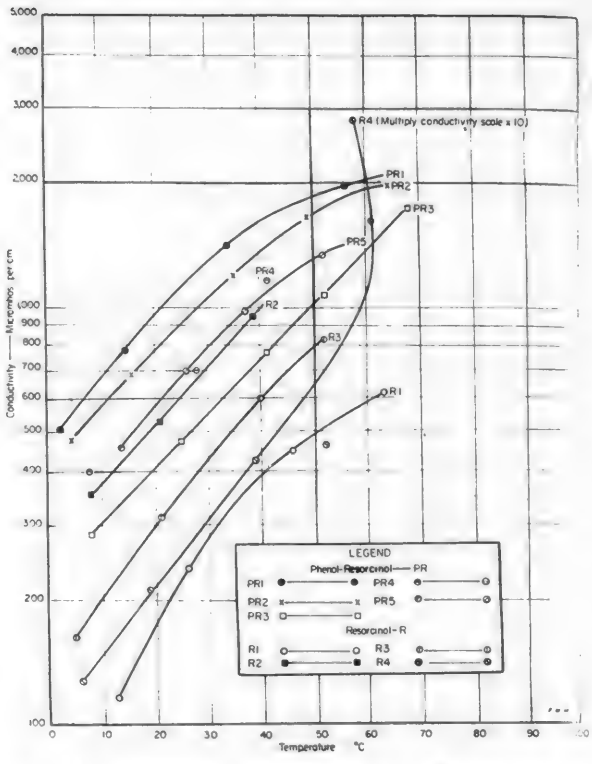


Fig. 11.—Conductivity v. temperature at 3 mc for resorcinol and phenol-resorcinol resins (catalyzed).

resorcinols and phenol-resorcinols are suspended in methanol (k = 40) containing some water. Sample R1 has a much higher proportion of solids than do the other samples.

Not enough points are available for the catalyzed glues in most cases to see any definite trend with temperature. Depending on the amount and nature of the catalyst added, the dielectric constant decreases, stays almost unchanged, or increases relative to that of the liquid resin, These effects are more noticeable with the resorcinols and phenol-resorcinols, of which all but sample R1 require the addition of 20 per cent of powdered catalyst, which should lower the dielectric constant. Sample R1 requires 25 per cent of liquid catalyst, which would be expected to increase its dielectric constant.

Conductivity of a Urea against Amount of Added Catalyst, Water, or Salt: The variation of conductivity with the amount of catalyst, water, or salt added to a sample is shown in Figs. 13 and 14, respectively, for urea

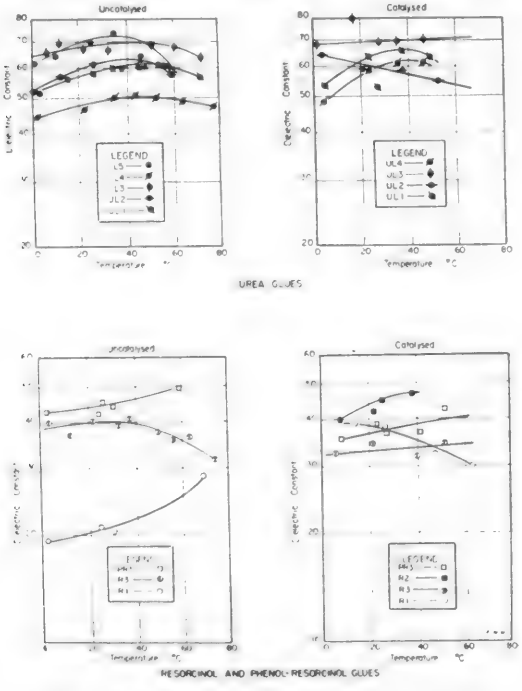
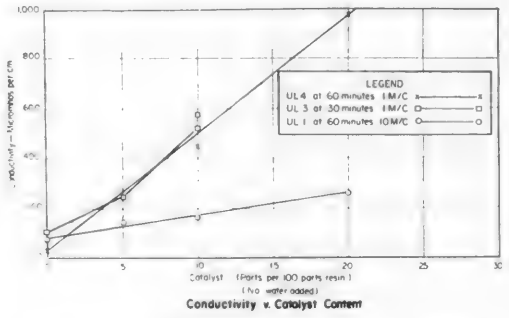


Fig. 12—Dielectric constant v. temperature at 3 mc.


LEGEND
UL4 at 60 minutes 1 M/C
UL 3 at 30 minutes 1 M/C
UL 1 at 60 minutes 10 M/C
Conductivity — Micromhos per cm
Catalyst (Parts per 100 parts resin)
(No water added)
Conductivity v. Catalyst Content

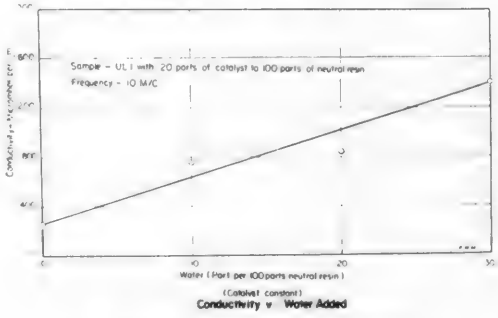

Sample – UL1 with 20 parts of catalyst to 100 parts of neutral resin
Frequency – 10 M/C
Conductivity — Micromhos per cm
Water (Part per 100 parts neutral resin)
(Catalyst constant)
Conductivity v. Water Added

Fig. 13.—Conductivity v. water added.

sample UL1. The variation of conductivity with amount of catalyst for two other urea samples (UL3, UL4) is also shown in Fig. 13.

In Fig. 13 conductivity increases almost directly with amount of catalyst added. Also in Fig. 13, conductivity increases almost directly with the amount of water added to catalyzed sample (UL1), which had 20 parts of catalyst to 100 parts of resin.

The conductivity in Fig. 14 increases directly with the amount of salt (sodium chloride) added to the uncatalyzed resin. For the catalyzed sample, the rate of increase of conductivity falls off at the higher salt concentrations. Thus, at a high concentration, the conductivity of a catalyzed sample is considerably lower than that of an uncatalyzed sample. No significant difference was observed between adding the salt before or after catalyst. As the salt concentration increases, the rate of change of conductivity with time decreases.

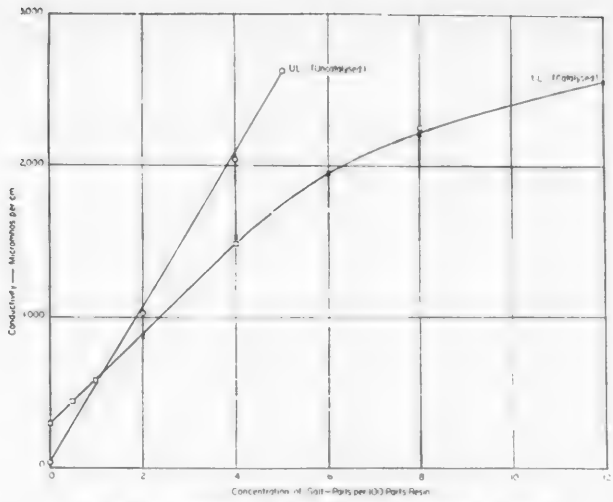


Fig. 14.—Conductivity v. salt concentration at 1 mc.

Summary

Conductivity at constant temperature and constant frequency for the group of resorcinol and phenol-resorcinol glues shows no variations with time during the working life of the glues. The conductivity for most of the group of urea glues falls off with time by about 10 per cent per hour during their working life. In two cases, the conductivity first decreases and then increases as the end of the working life is reached. The conductivity of the melamine glue shows a sharp drop around the end of its working life.

Dielectric constant, where measurable, shows no significant change with time, little change with temperature, and a slight decline with frequency. There is, after one hour of working life, a similar range of conductivities (250 to 3000 micromhos/cm) among the resorcinol, phenol-resorcinol, and urea glues tested, while the melamine glue tested is of exceptionally high conductivity at 9000 micromhos/cm. There is not much variation in conductivity with frequency for most of the catalyzed resins over the range covered.

Conductivity at a frequency of 3 mc for ureas, resorcinols and phenol-resorcinols shows a large increase with increased temperature within the test range of 0° to 80° C. for uncatalyzed resins and 0° to 60° C. for catalyzed glues. All samples tested seem to show substantially the same type of variation, so extrapolation to 100° C. seems a reasonable possibility and results in a six- to eight-fold increase in conductivity from room temperature to 100° C. All the urea glues that cured during this test at 50° to 60° C. showed a drop in their rate of rise of conductivity, whereas the resorcinols and phenol-resorcinols, with one exception (R4) that increased sharply, showed no change in their rate of rise of conductivity near the curing point.

The conductivity of one urea glue (UL1) tested at 1 mc increased with the concentration of added salt, but at a rate that decreased with increasing concentration and viscosity. The conductivity of this urea glue has found to increase directly with the amount of water added to make a less viscous mix. The conductivity of several urea samples was found to increase directly with the amount of catalyst added, but at various rates depending presumably on the ratio of electrolyte to filler material present in the catalyst.

Of special interest in the results obtained from this study is the decided increase of conductivity of most resin glues with temperature. Since the power supplied by a high-frequency field of constant voltage to a glue line parallel to it is a function of conductivity, this increase in conductivity with temperature can increase the power absorbed by the glue line and hence cause a high rate of temperature increase.

The fact that there is a wide variation in the conductivity of the glues studied suggests that there are great possibilities open to the glue manufacturers for developing resin glues with special dielectric properties that make them more suitable for use with radio-frequency heating.

For the user of radio-frequency heating in wood bonding operations, the results of this study confirm that there is a considerable variation in the dielectric properties of resin glues and, therefore, some glues may be better suited for use with radio-frequency heating than others.

Further work is required to combine data on the dielectric properties of resin glues with allied data on their thermo-setting properties, and thus establish a criterion of merit based on the cure time under fixed conditions of radio-frequency heating. This is one of the projects included in the current program of work of the Forest Products Laboratories of Canada.

Discussion

R. K. Stensrud (Reichhold Chemicals Inc.): Did you consider acid-catalyzed phenolics in this study? On the Pacific Coast more of this type is probably used than any other.

Mr. Miller: The number of glues included in the original study covered by this paper was limited by the fact that the procedure is rather time-consuming. We are continuing work on the dielectric properties of resin glues, and it is our intention to include measurements on acid-catalyzed phenols.

John Reno (Pacific Lumber Co.): Did you make joints for the test using the same samples of glue?

Mr. Miller: No.

Mr. Reno: Can you at this time give any specific recommendations to manufacturers or users based on your findings?

Mr. Miller: The results of this study show that some glues have dielectric properties that make them more suitable for use with R. F. heating than others. The user employing R. F. heating for parallel heating or for stray-field heating should, therefore, ensure that the glue he is using is one of those having good dielectric properties. At present, the only way the user can do this is to try out different glues in his operation. The ideal glue for use with R. F. heating should have 1) high arc resistance so it will not burn, 2) good dielectric properties that is, high conductivity and high dielectric constant values so that the glue will be heated selective and 3) good ther-

mo-setting properties so that the glue will cure quickly after being heated.

We hope to develop a simpler method of measuring the dielectric properties or resin glues that could be used by both the glue manufacturer and the glue user.

W. P. Johnson (The Borden Co.): What was the mixed age of the samples when measured? How did the properties vary with mixed age? Since the degree of polymerization would vary with temperature, was any adjustment made for "effective" mixed age at the different temperatures? How important are the dielectric properties in perpendicular gluing?

Mr. Miller: For the conductivity against time tests, the mix age ranged from about 10 to 140 minutes in the case of the urea samples and from about 20 to 170 minutes in the case of the resorcinol and phenol-resorcinol samples. The values in Tables 1 and 2 were adjusted to bring them to an arbitrary mix age of one hour at a temperature of 25° C. In perpendicular gluing where the plane of the glue lines is at right angles to the R. F. field, the dielectric properties of the glue are of little importance because the glue lines are heated for the most part by thermal conduction of heat from the adjacent wood. In parallel heating and stray-field heating, on the other hand, the dielectric properties of the wood are important because they affect the degree of selective heating and hence, the efficiency of the operation.

A. A. Marra (University of Michigan): Changes in conductivity as great as 400 per cent seem to exist. Assuming no change in inherent thermosetting properties, what might be the effect of a change of that magnitude on the cure time, for example, of edge-gluing one-inch lumber normally requiring 60 seconds?

Mr. Miller: The conductivity of some catalyzed urea samples was actually over 15 times that of other catalyzed urea samples at 10 mcs. It is difficult to estimate the effect of this large difference in conductivity on cure time because so many factors are involved and data on some of them are limited. In edge-gluing birch lumber strips one inch thick and three inches wide, a change in the conductivity of the glue by a factor of 15 would probably result in a change in the cure time by a factor of four, that is in your example, the cure time might range from 30 to 120 seconds.

The Production Gluing of Random-Length Core Stock[1]

HERBERT B. REED

Chief Engineer, Raybond Electronics, Inc., Newton Highlands, Mass.

A process for the production gluing of lumber-core panels from random-length core stock is described. Random-length boards are ripped to 2-9/16-inch width, edge-glued, layed up on a belt, and cured in an electronic gluing press. The panels are automatically cut in 100-inch lengths.

"PRODUCTION GLUING of Random Length Core Stock" is the name of a process by which 40 per cent of the production of the core gluing facilities at the Darlington Veneer Company, Darlington, S. C., is obtained.

The process is important because it represents an integrated set-up for the production of edge-glued lumber cores with a minimum of waste. Anything we can do to reduce waste in our woodworking industries has at least two very definite benefits. The first, of course, is an immediate reduction in production costs. The second, and I believe most important, is a better husbanding of one of our most valuable natural resources. This of course results from increasing the yield from raw material to the finished product.

The benefits derived from the random-length gluing process are due, in the main, to three factors. First is the improvement in the design of gang rip saws, which makes it possible to edge-glue stock directly from this type saw. The second factor is the extensive use of automation in materials handling, which affords a substantial reduction in labor costs. The third factor is the electronic gluing press and automatic cut-off saw, which make, in effect, a dual-purpose gluing machine. The press can batch-glue standard-size core panels or continuously glue a core panel strip (for want of a better term) of random-length boards from which panels of any length may be cut.

Fig. 1.—Out-feed of gang rip saw onto sorting belt.

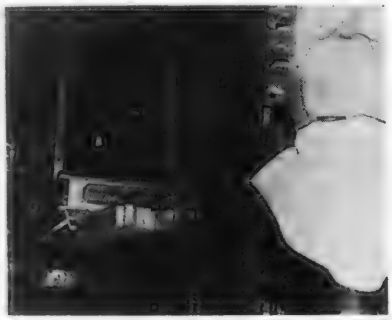


Fig. 2.—In-feed end of glue spreader.

The equipment is used to glue 4/4 softwood core stock, that is subsequently used for lumber cores in the woodworking industry.

All stock to be glued is first put through a double planer, where it is faced on both sides. From the planer, it is transferred automatically by a conveyor system to a cut-off saw. The cut-off saw operator removes major defects and cuts, as far as possible, standard lengths of 5, 6, 7 and 8 feet. All lengths less than standard are squared at the cut-off saw.

From the cut-off saw, all stock goes by conveyor chain to a gang rip saw, where it is ripped into 2-9/16 inch widths. The saw delivers stock directly

[1] Presented at Session VI, Glues and Gluing, FPRS 10th National Meeting, June 3–8, Asheville, N. C.

The Author: Herbert B. Reed holds a B. in Engineering from the University of New Hampshire, and is a registered P.E. in Wisconsin. He was Maintenance Engineer on the first and largest commercial installation of dielectric heating in the U.S., and has been associated with the M & M Woodworking Co., Thermex Div. of Girdler Co., Industrial Electronics Div. of Raytheon Mfg. Co. and Bell Machine Co.

to a sorting belt (Fig. 1) from which boards without major defects are removed and sorted into the four standard lengths. These, of course, are subsequently glued by conventional lay-up methods into standard-length panels.

Short lengths without defects are piled separately. All pieces with defects are sorted out and taken to a defect saw. By cutting out defects after gang ripping, a distinct reduction of waste is obtained because defective section are only 2-9/16 inches wide. Thus a minimum of good material is removed with the bad.

In a further step towards reduction of waste, all edge trimmings from the rip saw that are slightly less than 2-9/16 inches wide are re-ripped to 1½ inches and also glued into panels. Pieces narrower than 1½ inches are used for stickers in the dry kilns.

In the random-length gluing operation, all the odd-length pieces obtained from the cut-off and defect saws are delivered to the conveyor-type glue spreader. They are placed on edge on the glue spereader's in-feed conveyor. (Fig. 2) This conveyor automatically carries them over a glue roll, which coats one edge with urea-resin glue. They are then assembled manually on the lay-up table of the electronic gluing press (Fig. 3). This table is, in reality, a 50-inch-wide conveyor that extends completely through the press. The boards are laid up with end joints staggered, exactly the way the joints are staggered in a floor. In this lay-up operation, no attempt is made to forcibly butt the ends of individual boards. They are merely placed in position on the conveyor. When the conveyor is filled, it is started by the operator and it moves ahead 100 inches, the length of the press electrode.

Assume that you started watching the operation at some time during a regular production run. This would then mean that the boards just assembled on the conveyor are, in actuality, the continuation of a panel already in the press and being cured, while the ones under observation were laid up.

When the conveyor has traveled its 100 inches, an antomatic indexing device actuates an air-operated hold-down clamp. This clamp, at the out-feed end of the press, comes down on the panel being ejected and immediately stops its forward motion. Although the panel is held stationary, the conveyor keeps running for a few seconds. The continuing forward motion of the conveyor brings all the butt joints of the random-length boards into close contact with each other. After a few seconds of conveyor operation, a timing relay stops the conveyor, after which, in automatic sequence, the press

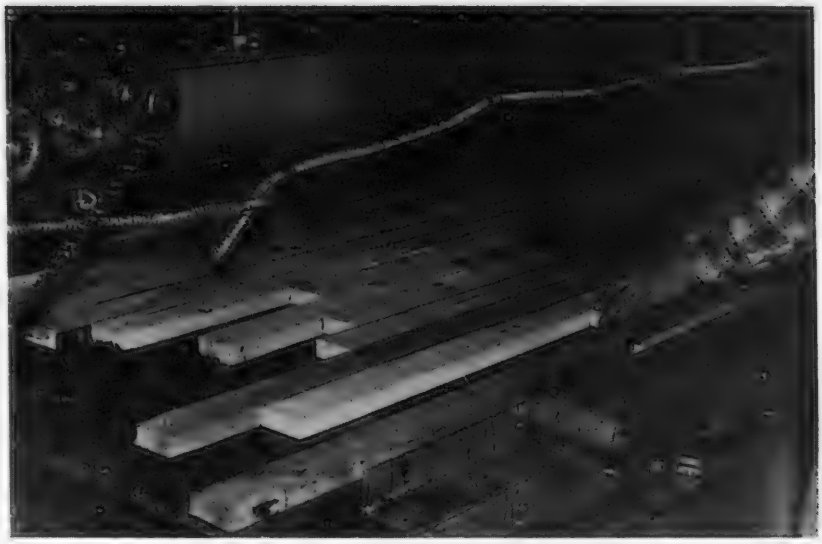


Fig. 3.—Random-length lay-up on press in-feed table.

closes, edge pressure is applied to the panel assembly, and high-frequency power is turned on to cure the glue.

During the curing cycle, an additional assembly of stock to be glued is placed on the in-feed conveyor. When the press automatically opens at the end of the curing cycle, the new load is run into the press as previously described.

Assume that finished panels eight feet long are desired. Just beyond the air operated hold down is an automatic cut-off saw, and beyond this, an adjustable positive stop. This stop will then be positioned eight feet from the cut-off saw. When the end of the cured panel being ejected from the press strikes the stop, its forward motion ceases. At the same time, a switch mounted on the stop is tripped by the panel. This time, however, the press stays open and the automatic cut-off saw goes into action, trimming the panel to the desired length (Fig. 4). After the saw has completed its cut and returned, the hold-down automatically lifts, the adjustable stop also lifts to allow the panel to pass under it, and the conveyor automatically restarts to complete the rest of its 100-inch travel.

Some of the special design features of the edge-gluing press which contribute to the successful operation of the equipment should be described.

First is the application of a variable timing relay in the circuit so that the conveyor may continue to run after the automatic indexing device has actuated the hold-down clamp to arrest the forward motion of stock. As these things have a way of doing, the incorporation of the timing relay posed a secondary problem. The press indexing unit is driven from the conveyor drive shaft. It is apparent that, if the indexing unit is set to stop the forward motion of stock after 100 inches of conveyor travel and yet allow the

Fig. 4.—Glued panel being cut to length at out-feed end of press.

conveyor to travel a few seconds longer, the next indexing operation will be less than 100 inches. This was solved by incorporating a magnetic clutch in the indexing unit drive train and designing the control circuit in such a way that when the indexing unit operates to stop the stock travel, the magnetic clutch is instantly de-energized to disconnect it. In this way, the indexing unit does not rotate at any time when the conveyor is running and stock is held stationary by the hold-down clamp.

While the use of an air-operated hold-down clamp is admittedly commonplace, making a single hold-down clamp serve a dual purpose is a step towards simplicity of design. The hold-down clamp is located at the out-feed end of the press immediately ahead of, and close to, the cut-off saw. It does double duty. In the gluing operation, it serves to arrest the forward motion of stock before the conveyor stops in order to close up the end joints of random-length boards. It is also actuated automatically to serve as a clamp when the cut-off saw is in operation.

In designing the automatic cut-off saw, two alternatives were available by which variable-length panels could be obtained. An adjustable trip could have been used in combination with a traveling cut-off saw to cut panels while they were being ejected from the press. The other possibility was an adjustable positive stop, and a cut-off saw fixed in position with respect to the out-feed table so that the panel would have to stop momentarily while being trimmed. In the interest of simplicity, dependability, and accuracy of cut, the latter arrangement was chosen. Panels being ejected from the press strike a positive stop, which instantly stops their forward motion. At the same time, a limit switch is actuated, which energizes the hold-down clamp, stops the conveyor, and starts the trim-saw feed motor. The saw itself is an 18-inch blade, driven at 3400 rpm by a 7½ hp motor. It makes its cut and returns in 6 seconds. Interlocks are provided to prevent the saw-carriage feed motor from operating unless the saw motor is running.

While an attempt to make one machine do several different jobs usually results in a piece of equipment that does no job well, there is, however, the possibility of designing equipment so that it may be as versatile as possible, within the limits of its intended function. With this in mind, the control circuit of the edge-gluing press was laid out in such a way that the positioning of two switches on the control panel sets up the circuit for four types of operation.

First, it may be operated as a simple, manually controlled, edge-gluing press. Conveyor travel is under manual control. Press closing cycles are automatic. The cut-off saw does not function.

Second, it may be operated as an automatically indexing, edge-gluing press. The conveyor moves a load into the press, stops automatically, and the press closes and glues the stock. The cut-off saw does not function. The indexing device may be set for batch gluing of short panels or for continuous gluing of long lengths.

Third, the unit may be operated as a manually fed edge-gluing press, with the automatic trim saw cutting panels to any desired length.

Fourth is the operation described here, that is, as an automatically indexing, edge-gluing press, with automatic trim saw cutting panels to desired lengths.

A discussion of the edge-gluing equipment would not be complete without a description of the high-frequency generator. It has a power output of 20 kw and employs capacative coupling to the press electrodes. Its frequency range is 4 to 5 megacycles, which is low enough to require no tuning stubs of any kind on a 100-inch electrode, yet high enough not to build up excessive voltages across the load to cause arcing and flashover. The average curing cycle is 30 seconds.

To summarize briefly, this entire installation, designed expressly for the edge gluing of random-length core stock, has increased the yield, based on finished panel sizes, from 60 per cent to 68 per cent. This means an actual increase in yield of 13 per cent. It is made possible by utilizing lumber for whatever length it produces, and by removing as little good material as possible with defective portions. Production rates of 10,000 board feet per single-shift day have been attained. It is also reported that the panels glued of random-length stock tend to stay flatter than the conventional-type panels.

Discussion

Milton H. Mater (Mater Engineering): Is this a batch operation?

Mr. Reed: Yes, one panel is laid at a time.

Mr. Mater: Is 100 inch limit of length?

Mr. Reed: No, the electrode is 100 inches but you can make longer pieces by end-gluing panels or by indexing the longer panel forward in 100-inch lengths.

Mr. Mater: What is the speed of gluing?

Mr. Reed: The average curing cycle is 30 seconds.

Mr. Mater: Why are the pieces ripped to 2-9/16 inches in width?

Mr. Reed: This width was chosen by our customer as best suited for his manufacturing process. The equipment will glue any stock width.

Mr. Mater: Do edges need any further finishing before glue spreading?

Mr. Reed: No, the stock is glued directly from a gang ripsaw.

E. P. Ivory (Ivory Pine Co.): Is the glue joint damaged if the panel remains beyond the 30-second cycle

Mr. Reed: No. You can leave it a long time. As soon as the glue joint is dry, heat then goes into the wood but does not damage the glue joint

Mr. Ivory: Is any glue applied on ends?

Mr. Reed: No, glue is not applied to the end joints. They are merely butted together.

Boyd Richards (Alabama Polytechnic Institute): What does this whole operation cost per thousand board feet?

Mr. Reed: I have no figures on the production cost per thousand board feet.

Peter Koch (Michigan State University): How do you keep the ends from misaligning when you apply edge pressure?

Mr. Reed: The top platen comes down and puts 3 psi on the board surfaces, which holds them in place when edge pressure is applied.

B. B. Lane (The Lane Co.): Can this process be used for hardwoods?

Mr. Reed: There is no reason why it could not be used with hardwood—with proper care.

Mr. Lane: What is the end use of this core stock?

Mr. Reed: It was poplar core stock used for veneered paneling.

Mr. Lane: Is the quality high enough for use as finished furniture panels?

Mr. Reed: It would not be suitable for high-quality furniture panels

R. D. White (Brunswicke–Balke–Collender Co.) What is the recommended minimum distance between end joints in adjacent boards?

Mr. Reed: About 12 inches.

Mr. White: What is the minimum length useable?

Mr. Reed: About 12 inches.

The Relative Preservative Tolerances of 18 Wood-Destroying Fungi[1,2]

ELLIS B. COWLING

Threshold values are presented which indicate the comparative tolerances of 18 wood-destroying fungi to 10 preservatives. Marked variations are shown. Implications are discussed in relation to preservative evaluation and decay control, and studies of fungal physiology. A rapid laboratory procedure is described for determining thresholds with impregnated wood blocks.

Introduction

AN IMPORTANT LIMITATION to the usefulness of wood is its susceptibility to decay in particular conditions of storage and use. When wood is permitted to contain water in excess of its fiber saturation point, it is susceptible to invasion by wood-destroying fungi. Decay will result unless the wood is naturally durable or has been properly treated with a preservative. Many toxic chemicals have been used as wood preservatives, but not all are equally effective in preventing decay by the various fungi that attack wood products. Different species of fungi exhibit different levels of tolerance to toxicants; some species are able to decay wood that contains considerable amounts of preservatives. Knowledge of the levels of preservative tolerance shown by wood-destroying fungi has importance in recommending suitable types and amounts of preservatives for various wood products. It may also aid in the selection of proper organisms with which to evaluate new preservatives, and in explaining occasional failures of preservative treatments.

This study was undertaken to determine the comparative tolerances of 18 economically important fungi to ten preservatives of present or potential importance.

Review of Literature

In 1954, Zabel (8)[3] reviewed earlier literature regarding the preservative tolerances of wood-inhabiting fungi. He also presented the results of tests that demonstrated the striking tolerance of *Lentinus lepideus* to creosote, *Poria monticola* to copper naphthenate, and *Lenzites trabea* to pentachlorophenol and phenyl mercury oleate. The following more recent reports emphasize additional instances of this phenomenon.

Differences in preservative tolerance among 25 isolates of *Lentinus lepideus* were shown by Schultz (6). The ratio of highest to lowest threshold[4] determined for these isolates was 3.8 for pentachlorophenol, 3.4 for copper naphthenate, and 2.5 for creosote.

Resistance to copper naphthenate by several brown-rot fungi was found by Duncan (4). *Fomes subroseus, Poria cocos, P. incrassata, P. vaillantii, P. xantha,* and 20 of 28 isolates of *P. monticola* showed unusual resistance to this preservative. She concluded that variations in preservative tolerance within certain species may equal those between species. When toluene was used alone as the carrier, these fungi decayed blocks containing from three to more than six times the amount of copper naphthenate that prevented decay when a mixture of toluene and a high-boiling aromatic oil was used as the carrier. The apparently synergistic influence of the aromatic oil on the effectiveness of this preservative warrants further study.

Each of these reports indicates several instances of preservative tolerance. The tolerance levels of many additional fungi that decay wood products have not been reported. This lack of published data suggested the present investigation.

Materials and Methods

Comparable threshold values for 180 combinations of fungus and preservative were determined by an adaptation of the conventional agar-block decay test (1). Modifications were made in the usual test procedure to facilitate rapid deetrmination of threshold values. The major experimental variables in this study were: 18 fungi, 10 preservatives, and 8 preservative retention levels. Five replicates were used per test category. Sixteen untreated control blocks were used for each fungus.

Test Fungi: The 18 fungous cultures used in this study[5] are listed in Table 1. These species include economically important brown- and white-

[1] Part of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at the State University of New York College of Forestry in the Dept. of Forest Botany and Pathology under Dr. Robert A. Zabel.

[2] 1957 Wood Award Entry

[3] Numbers in parentheses refer to literature cited.

The Author: Ellis Cowling holds B.S. and M.S. degrees from the State University of New York College of Forestry. He is presently engaged in a doctorate program in plant pathology at the University of Wisconsin. His research for this degree is on the mechanism of enzyme action in wood decay, and is being completed in the Division of Wood Preservation, U.S. Forest Products Laboratory, Madison, Wis.

[4] The threshold value of a preservative is defined as the least amount of the preservative (based on initial retention in the wood) that will prevent decay by a given fungus under specified test conditions.

[5] In selecting the organisms for study, a list of nearly 100 species associated with decay of wood products was compiled from the literature. The fungi were classified by the type of product affected, the nature of the decay, and their frequency of association with decay. The list is available from the author and appears in the PLANT DISEASE REPORTER, Vol. 41, pp. 894-896. *Polyporus tulipiferae* has not been found in association with decay of wood products but was included in this study because it has been commonly used as a decay-test organism (3).

Table 1.—FUNGI SELECTED FOR TESTS OF PRESERVATIVE TOLERANCE GROUPED ACCORDING TO FAMILY

Name of Fungus		Isolate Number*
Agaricaceae		
Lentinus lepideus Fries	(B)†	Madison 534-R
Schizophyllum commune Fries	(W)	56473
Polyporaceae		
Daedalea quercina L. ex Fries	(B)	53396-S
Fomes subroseus (Weir) Overholts	(B)	Madison 701
Lenzites saepiaria (Wulf. ex Fries) Fries	(B)	Madison 604
Lenzites trabea (Pers. ex Fries) Fries	(B)	Madison 617
Lenzites trabea (Pers. ex Fries) Fries	(B)	Madison 539
Poria incrassata (Berk. & Curtis) Burt	(B)	Madison 563
Poria monticola Murr.	(B)	Madison 698
Poria monticola Murr.	(B)	94265
Poria vaillantii (DC. ex Fries) Cooke	(B)	94370
Poria xantha (Fries) Cooke	(B)	192
Polyporus abietinus Dicks. ex Fries	(W)	97099-S
Polyporus adustus Willd. ex Fries	(W)	71367-R
Polyporus hirsutus Wulf. ex Fries	(W)	R-92
Polyporus tulipiferae (Schw.) Fries	(W)	103389-R
Polyporus versicolor L. ex Fries	(W)	R-105
Thelephoraceae		
Stereum frustulosum (Pers.) Fries	(W)	56461-R

*Isolate numbers refer to cultures maintained in the Division of Forest Disease Research, Plant Industry Station, Beltsville, Maryland.
†(B) indicates brown-rot fungi; (W) indicates white-rot fungi.

rot fungi from three families of Hymenomycetes. Two isolates of the important test fungi *Lenzites trabea* and *Poria monticola* were included to detect possible differences between separate isolates of these species.

Preservatives: The preservatives used in this investigation are listed in Table 2. The list includes the five materials most widely used in 1955 (5), and five others suggested as potentially important by nine firms that produce or distribute wood preservatives.

In order to determine thresholds for the susceptible as well as the tolerant fungi tested, eight solutions forming a progression of increasing concentrations of each preservative were used to treat test blocks. These concentrations were established considerably above and below anticipated "average" threshold values (designated T), which were estimated from the literature and preliminary tests. Treating solutions of each preservative were prepared in the following concentrations by diluting aliquots of master solutions: 0.10T, 0.35T, 0.70T, 1.15T, 1.70T, 2.35T, 3.10T, and 3.95T. Analytical data, anticipated "average" threshold values, and the solvent used for each preservative are given in Table 2.

Preparation and Treatment of Test Blocks: The test blocks were cut from ponderosa pine sapwood (*Pinus ponderosa* Laws.), and measured 0.5 inch in the radial direction, 1.25 inches tangentially, and 0.25 inch in the longitudinal direction. The blocks were randomly assigned to the various treatment groups after they were conditioned to equilibrium in an atmosphere at 28° C. and 67 per cent relative humidity.

The test blocks were treated in groups of 90 by soaking in agitated preservative solutions for one hour. Each group of blocks was weighed to the nearest 0.1 gram before treatment and again after removal from the treating solution. The blocks were permitted to drain on wire screens for one minute before the second weighing. The average amount of preservative absorbed by the blocks in each treatment group, expressed in pounds of preservative (without solvent) per cubic foot of wood, was calculated from the weight gained during treatment and the concentration of treating solution used.

Preliminary study of variation in preservative absorption among individual test blocks treated by this soaking method gave coefficients of variation of 9.7 per cent for creosote, 7.9 per cent for the oil-soluble preservatives, and 6.9 per cent for the water-soluble preservatives. These coefficients were constant for all concentrations of the treating solutions.

The treated test blocks were exposed to a forced draft of air at room temperature until constant weight indicated that the solvents and volatile portions of the preservatives had evaporated. Single blocks were then randomly selected from each of the eight groups treated with a given preservative. These blocks were fastened into rigid, planar series in order of increasing preservative retention. Each block was separated from its neighbors by 0.1 inch. Aluminum staples were used as fasteners (see Fig. 1) Similar series of untreated control blocks were prepared. The assembled test blocks were sterilized in steam at 101° C. for 30 minutes.

Preparation and Assembly of Decay Chambers: Sixteen-ounce French square bottles with loose-fitting screw caps were used as decay chambers. Approximately 50 milliliters of malt agar were placed in each chamber; the medium was sterilized and permitted to gel with the chambers set on their sides. The chambers were inoculated by aseptically planting two 6-millimeter discs of actively growing mycelium about 1.5 inches from opposite ends of the chambers. After incubation for ten days at 28° C., the fungi had formed mats of mycelium over the agar surface. Sterile 2-millimeter glass rods were placed on these mycelial mats to support the sterilized series of test blocks that were then installed

Five replicate chambers were prepared for each combination of the 18 fungi and 10 preservatives tested. Two control chambers containing a series of untreated test blocks were prepared for each fungus. Sample chambers in various stages of assembly and incubation are shown in Fig.

Determination of Threshold Values: The assembled decay chambers were incubated for a period of five weeks at 28° C. and 65 to 70 per cent relative humidity. Each chamber was examined every third day, and visible evidence of fungal penetration of the test blocks was recorded. At the end of the incubation period, the chambers were opened, the series of test blocks were removed, and threshold values were determined.

The following criteria were used to separate blocks decayed by the fungus

Table 2.—PRESERVATIVES GROUPED ACCORDING TO TYPE WITH SOLVENT, ACTIVE INGREDIENTS, AND ANTICIPATED "AVERAGE" THRESHOLD (T) VALUE FOR EACH MATERIAL

Name and type of preservative*	Active ingredients in the preservative Per cent, weight basis		Concentration of treating solution at anticipated "average" threshold (T) value†
Oily Type Preservative: (solvent—Solvasol No. 5‡)			
1. Creosote	See footnote§		15.00
Oil-Soluble Preservatives: (solvent—Solvasol No. 5‡)			
2. Pentachlorophenol	Chlorinated phenols	95	0.75
3. Copper Naphthenate	Copper naphthenate	80	
	Copper (as metal)	8	0.50‡‡
4. Copper-8 Quinolinolate	Solubilized copper-8 quinolinolate	10	0.30
5. Rosin Amine D Pentachlorophenate	Rosin amine D pentachlorophenate	40	3.00
6. Phenyl Mercuric Oleate	No analytical data available; compound presumed pure		0.03
Water-Soluble Preservatives: (solvent—distilled water)			
7. Chromated Zinc Chloride	Zinc chloride	77.5	
	Sodium dichromate	14.6	
	Chromic acid	2.2	
	(Total hexavalent chromium as sodium dichromate	17.9)	0.60
8. Tanalith (Wolman salts)**	Sodium fluoride	25	
	Disodium hydrogen arsenate	25	
	Sodium chromate	37.5	
	Dinitrophenol	12.5	0.30
9. Acid Copper Chromate**	Copper sulfate	50	
	Hexavalent chromium calculated as sodium dichromate	47.5	
	Chromic acid calculated as equivalent to 2.5% sodium dichromate	1.68	0.40
Miscellaneous Preservative: (solvent—75% acetone, 25% methyl cellosolve)			
10. Copper Pentachlorophenate	No analytical data available; compound presumed of same purity as pentachlorophenol		0.75

*The preservatives were obtained from the following firms: No. 1 from the Bell Telephone Laboratories, Murray Hill, N. J.; No. 2 as "Dowicide 7", and No. 10 from The Dow Chemical Co., Midland, Mich.; No. 3 as "Nuodex Copper 8%" from Nuodex Products Co., Elizabeth, N. J.; No. 4 as "Cunilate 2174", and No. 5 as "Cunimene D-2629" from The Scientific Oil Compounding Co., Chicago, Ill.; No. 6, and No. 7 as "CZC" from E. I. DuPont de Nemours and Co., Wilmington, Del.; No. 8 and No. 9 as reagent grade ingredients from Fisher Scientific Co., New York, N. Y.

†Estimated from the literature and preliminary tests and expressed as per cent, weight basis, of active ingredients in the treating solution. Master solutions contained 3.95 times this amount.

‡Solvasol No. 5, a product of the Socony-Vacuum Oil Company, Inc., has approximately 20% aromatic content and a flash point of 103° F.

§Analytical composition as given by the Bell Telephone Laboratories: Distillation fractions: 0-210° C.—0.69%, 210-235° C.—15.77%, 235-270° C.—29.00%, 270-315° C.—17.68%, 315-355° C.—19.21%, residue above 355° C.—17.40%; Specific gravities at 38/15.5° C.: whole oil—1.065, 235-315° C. fractions—1.030, 315-355° C. fraction—1.108; Benzol insoluble—0.2%; Coke residue (in oil)—1.36%; Sulfonation residues (210-355° C. fractions)—1.25 ml/100g; Tar acids (210-355° C. fractions)—5.70 ml/100g.

The master solution of pentachlorophenol contained 2% pine oil as booster solvent.

‡‡It is conventional to express concentration of copper naphthenate as weight of metallic copper in the solution.

**Prepared according to specifications given in the American Wood-Preservers' Association Manual of Recommended Practice (2).

from those protected by the preservative in each decay chamber: 1) Blocks not contacted by the mycelium were considered free of decay. 2) Blocks exhibiting obvious breakdown of the wood substance or extreme loss of strength were considered decayed. 3) Blocks on which the mycelium appeared first on the upper surface after penetrating the block were considered decayed. (Preliminary study showed a high correlation between penetration by the mycelium and the presence of hyphae and bore holes in the wood.) 4) Blocks subjected to brown-rot fungi were oven dried; those deformed by drying were considered decayed. 5) Blocks not otherwise classified were examined microscopically and those containing hyphae and bore holes were considered decayed.

These criteria were used to select from each decay chamber the test block that contained the least amount of preservative, and yet showed no decay. The average retention of preservative in the treatment group of which that block was a member gave an approximate threshold value. The approximate values for the five replicates of each combination of fungus and preservative were averaged to give mean threshold values.

Comparison of the Mean Thresholds: Statistical evaluation of differences among several mean values requires a valid estimate of the standard error of the means. No such estimate was available for comparison of the mean thresholds due to heterogeneity of variance, a condition that resulted from the range of treating concentrations used[6] and the fact that the blocks indicating approximate thresholds in replicate chambers were not always members of the same treatment group. A conservative basis of comparison was employed, however, that made use of the two standard deviation limits of preservative retention in the individual blocks in the various treatment groups[7]. These limits were calculated from the coefficients of variation described earlier. When the block indicating an approximate threshold in each decay chamber was selected, the two standard deviation limits as well as the mean preservative retention in the treatment group of which that block was a member were determined. The highest and lowest of these limits, given by the five replicates of a given combination of fungus and preservative, provided limits for the mean threshold determined for that same combination.

[6] Variation among test blocks in the amount of preservative retained is a function of the concentration of the treating solution used. This fact is often neglected in preservative tests.

[7] The method is analogous to using the standard deviation of individuals instead of the standard error of means as a measure of discrepancy in Student's t-test.

Fig. 1.—Decay chambers in various stages of assembly and after three weeks' incubation. A—agar gel in sterile decay chamber; B—mycelial mat of *Poria monticola* covering agar surface; C—2-millimeter glass rods placed on mycelial mat to support test blocks; D—test blocks treated with copper naphthenate installed (transverse surfaces up); E—mycelium of *P. monticola* after penetrating three of eight blocks treated with creosote.

Mean thresholds whose limits did not overlap were considered significantly different.

This is an extremely conservative basis for comparison of the mean thresholds. Moderate but statistically significant differences among some of the organisms may have been obscured. However, a relative measure of the preservative tolerances of the fungi was provided.

Results

The mean thresholds and limits determined for the various test fungi are presented in Table 3, arranged in order of decreasing value for each preservative[8]. The test fungi are divided into three classes: I–tolerant, II–median, and III–susceptible. Thresholds for the fungi in class I are significantly different from those in class III since their limits do not overlap. Class II includes fungi of median resistance to the preservatives. Species whose threshold indicated unusual and heretofore unreported tolerance to a given preservative are marked with an asterisk. The tolerance indexes in Table 3 are the ratios of the highest to the lowest mean threshold determined for each preservative. All control blocks showed extensive decay after the 5-week incubation period.

The mean thresholds in Table 3 are approximate, as is indicated by the limits that accompany them. They are somewhat lower than comparable ones determined by other test methods. This was due in part to the soaking treatment method, which resulted in relatively poor distribution of the preservatives in the inner portions of the test blocks.

Unusual tolerance to one or more of the preservatives was shown by 14 of the 18 fungi tested. The number of species considered tolerant to a given preservative varied from two for creosote, pentachlorophenol, and copper pentachlorophenate to seven for acid copper chromate.

The tolerance indexes in Table 3 range from seven for rosin amine D pentachlorophenate to 40 for acid copper chromate. These values indicate the magnitude of differences between the amounts of preservative needed to control the most tolerant and the most susceptible of the fungi tested.

Certain fungi showed unusual tolerance or susceptibility to each preservative. *Fomes subroseus* and *Polyporus tulipiferae* were unusually tolerant to eight of the ten preservatives tested. *Stereum frustulosum* was markedly tolerant to phenyl-mercuric oleate as was *Lentinus lepideus* to creosote, although both fungi were susceptible to most other preservatives. *Poria vaillantii* was moderately tolerant to acid copper chromate and chromated zinc chloride, but was susceptible to all other preservatives. *Schizophyllum commune* was susceptible to all preservatives except creosote, as was *Polyporus abietinus* to all except rosin amine D pentachlorophenate.

The two isolates of *Lenzites trabea* and *Poria monticola* showed different patterns of resistance to the preservatives. Isolate A of *L. trabea* showed greater tolerance to most of the preservatives than isolate B of that species. The isolates of *P. monticola* showed appreciable differences in tolerance to

[8] Thresholds for copper pentachlorophenate were omitted from Table 3 because of an apparent toxic vapor effect. This was probably induced by the methyl cellosolve used as solvent. Only *Fomes subroseus* and *Polyporus tulipiferae* caused decay in blocks treated with this preservative.

Table 3.—THE TEST FUNGI ARRANGED IN ORDER OF DECREASING TOLERANCE TO THE PRESERVATIVES TESTED. CLASS I INCLUDES ORGANISMS SIGNIFICANTLY MORE RESISTANT THAN THOSE IN CLASS III. THE TOLERANCE INDEXES ARE THE RATIOS OF THE HIGHEST TO THE LOWEST MEAN THRESHOLD FOR EACH PRESERVATIVE. FUNGI MARKED WITH AN ASTERISK SHOWED THRESHOLDS THAT INDICATE TOLERANCE THAT HAS NOT BEEN WIDELY REPORTED.

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	CREOSOTE (Tolerance Index 15)		
I	Lentinus lepideus	3.08	2.05-4.67
	Poly. tulipiferae*	3.08	2.05-4.67
II	Lenzites trabea A	1.47	1.18-1.76
	Lenzites trabea B	1.32	0.56-1.76
	Poly. adustus	1.16	0.56-1.76
	Poly. hirsutus	1.16	0.56-1.76
	Poria monticola B	0.85	0.56-1.76
	Schiz. commune	0.85	0.56-1.76
	Lenz. saepiaria	0.69	0.56-0.83
	Ster. frustulosum	0.69	0.56-0.83
	Poria xantha	0.53	0.16-0.83
	Poria monticola A	0.40	0.16-0.83
	Poly. versicolor	0.40	0.16-0.83
III	Fomes subroseus	0.20	0.16-0.24
	Daedalea quercina	0.20	0.16-0.24
	Poria incrassata	<0.20	-
	Poria vaillantii	<0.20	-
	Poly. abietinus	<0.20	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	PENTACHLOROPHENOL (Tolerance Index 22)		
I	Fomes subroseus*	0.24	0.16-0.30
	Poly. tulipiferae	0.11	0.074-0.14
II	Poria incrassata	0.075	0.074-0.076
	Poria monticola B	0.061	0.033-0.076
	Poly. adustus	0.061	0.033-0.076
	Poria monticola A	0.053	0.033-0.076
	Poly. versicolor	0.048	0.033-0.076
	Poly. hirsutus	0.043	0.010-0.076
III	Lenzites trabea A	0.039	0.033-0.044
	Lentinus lepideus	0.030	0.010-0.044
	Poly. abietinus	0.030	0.010-0.044
	Poria vaillantii	0.030	0.010-0.044
	Poria xantha	0.025	0.010-0.044
	Lenzites trabea B	0.022	0.010-0.044
	Daedalea quercina	0.022	0.010-0.044
	Lenz. saepiaria	0.011	0.010-0.013
	Schiz. commune	<0.011	-
	Ster. frustulosum	<0.011	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	COPPER NAPHTHENATE (Tolerance Index 24)		
I	Poria incrassata	0.17	0.10-0.26
	Poria monticola B	0.16	0.10-0.26
	Poria monticola A	0.15	0.10-0.20
	Poly. tulipiferae*	0.13	0.083-0.20
II	Fomes subroseus	0.070	0.021-0.08
	Daedalea quercina	0.056	0.042-0.08
III	Poly. hirsutus	0.049	0.042-0.05
	Lenzites trabea A	0.030	0.021-0.05
	Poly. adustus	0.030	0.021-0.05
	Schiz. commune	0.019	0.0061-0.02
	Lenzites trabea B	0.018	0.0061-0.02
	Ster. frustulosum	0.014	0.0061-0.02
	Poria vaillantii	0.014	0.0061-0.02
	Poria xantha	0.014	0.0061-0.02
	Lenz. saepiaria	0.011	0.0061-0.02
	Poly. versicolor	0.0071	0.0061-0.00
	Lentinus lepideus	<0.0071	-
	Poly. abietinus	<0.0071	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	COPPER-8 QUINOLINOLATE (Tolerance Index 8)		
I	Poria xantha*	0.038	0.026-0.056
	Poly. adustus*	0.030	0.026-0.034
	Poly. tulipiferae*	0.030	0.026-0.034
II	Poly. versicolor	0.028	0.013-0.056
	Poria monticola A	0.027	0.013-0.034
	Poly. hirsutus	0.024	0.013-0.034
III	Poria vaillantii	0.016	0.013-0.018
	Fomes subroseus	0.013	0.0039-0.018
	Poria monticola B	0.013	0.0039-0.018
	Ster. frustulosum	0.011	0.0039-0.018
	Poria incrassata	0.0089	0.0039-0.018
	Daedalea quercina	0.0045	0.0039-0.018
	Lenzites trabea A	0.0045	0.0039-0.0052
	Lenzites trabea B	0.0045	0.0039-0.0052
	Lenz. saepiaria	<0.0045	-
	Poly. abietinus	<0.0045	-
	Lentinus lepideus	<0.0045	-
	Schiz. commune	<0.0045	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	ROSIN AMINE D PENTACHLOROPHENATE (Tolerance Index 7)		
I	Poly. tulipiferae*	0.31	0.27-0.35
	Poria incrassata*	0.22	0.13-0.35
	Fomes subroseus*	0.19	0.13-0.35
	Poly. adustus*	0.16	0.13-0.18
II	Poly. hirsutus*	0.17	0.039-0.18
	Poly. abietinus	0.13	0.039-0.18
	Poria monticola B	0.10	0.039-0.18
	Lenz. saepiaria	0.10	0.039-0.18
	Poria monticola A	0.067	0.039-0.18
III	Poria xantha	0.045	0.039-0.051
	Lentinus lepideus	0.045	0.039-0.051
	Daedalea quercina	0.045	0.039-0.051
	Lenzites trabea A	0.045	0.039-0.051
	Lenzites trabea B	0.045	0.039-0.051
	Poly. versicolor	<0.045	-
	Poria vaillantii	<0.045	-
	Schiz. commune	<0.045	-
	Ster. frustulosum	<0.045	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	PHENYL MERCURIC OLEATE (Tolerance Index 39)		
I	Ster. frustulosum*	0.017	0.012-0.0
	Poly. tulipiferae*	0.0065	0.0026-0.01
	Poria monticola B*	0.0025	0.0026-0.0
II	Fomes subroseus*	0.0025	0.0013-0.0035
	Lenzites trabea A	0.0021	0.0013-0.0035
	Poria incrassata	0.0020	0.0013-0.0035
	Poly. versicolor	0.0020	0.00038-0.0035
	Daedalea quercina	0.0014	0.00038-0.0035
	Lenz. saepiaria	0.0014	0.00038-0.0035
III	Poria monticola A	0.0013	0.00038-0.0018
	Lenzites trabea B	0.0011	0.00038-0.0018
	Poly. hirsutus	0.00088	0.00038-0.0018
	Poria xantha	0.00088	0.00038-0.0018
	Poly. adustus	0.00071	0.00038-0.0018
	Lentinus lepideus	0.00066	0.00038-0.0018
	Poly. abietinus	<0.00044	-
	Poria vaillantii	<0.00044	-
	Schiz. commune	<0.00044	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	CHROMATED ZINC CHLORIDE (Tolerance Index 8)		
I	Poria monticola A*	0.42	0.29-0.67
	Daedalea quercina*	0.39	0.29-0.67
	Fomes subroseus*	0.39	0.21-0.53
	Poria monticola B*	0.33	0.21-0.53
	Poly. tulipiferae*	0.29	0.21-0.40
	Poria incrassata*	0.25	0.21-0.29
II	Poria vaillantii*	0.27	0.14-0.40
	Lenzites trabea B	0.23	0.14-0.29
	Lenzites trabea A	0.20	0.14-0.29
III	Lentinus lepideus	0.17	0.14-0.20
	Ster. frustulosum	0.14	0.087-0.20
	Poria xantha	0.12	0.087-0.20
	Poly. versicolor	0.11	0.043-0.20
	Lenz. saepiaria	0.10	0.087-0.12
	Poly. adustus	0.10	0.087-0.12
	Poly. hirsutus	0.082	0.043-0.12
	Poly. abietinus	0.050	0.012-0.12
	Schiz. commune	-----	----------

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	T/M/LITH (Tolerance Index 21)		
I	Lenzites trabea A*	0.14	0.10-0.19
	Fomes subroseus*	0.13	0.071-0.25
	Lenzites trabea B*	0.12	0.071-0.19
II	Poly. versicolor	0.086	0.042-0.14
	Poria incrassata	0.084	0.071-0.097
	Poria monticola A	0.077	0.042-0.097
	Poly. hirsutus	0.071	0.042-0.14
	Poly. tulipiferae	0.057	0.042-0.097
III	Daedalea quercina	0.050	0.042-0.058
	Lentinus lepideus	0.031	0.0067-0.058
	Poria monticola B	0.030	0.021-0.058
	Poria vaillantii	0.030	0.021-0.058
	Lenz. saepiaria	0.023	0.0067-0.058
	Ster. frustulosum	0.014	0.0067-0.028
	Poria xantha	0.013	0.0067-0.028
	Poly. adustus	0.010	0.0067-0.028
	Poly. abietinus	<0.0068	-
	Schiz. commune	<0.0068	-

	Test Fungi**	Threshold in Pounds per Cubic Foot# Mean	Limits
	ACID COPPER CHROMATE (Tolerance Index 40)		
I	Fomes subroseus*	0.36	0.30-0.41
	Daedalea quercina*	0.36	0.30-0.41
	Poria incrassata*	0.36	0.30-0.41
	Poria monticola A*	0.36	0.30-0.41
	Poria monticola B*	0.36	0.30-0.41
	Poria vaillantii*	0.36	0.30-0.41
	Poly. tulipiferae*	0.33	0.25-0.41
II	Poly. adustus	0.29	0.19-0.41
	Lenzites trabea A	0.23	0.09-0.34
	Ster. frustulosum	0.19	0.13-0.34
	Poria xantha	0.15	0.053-0.26
III	Lenzites trabea B	0.10	0.053-0.16
	Poly. versicolor	0.072	0.053-0.13
	Poly. hirsutus	0.057	0.028-0.07
	Lenz. saepiaria	0.028	0.0076-0.03
	Lentinus lepideus	0.019	0.0076-0.03
	Schiz. commune	0.0090	0.0076-0.01
	Poly. abietinus	<0.0090	-

#Mean thresholds and limits are expressed as the weight of the active ingredients in the preservatives as given in Table 2

**Lenzites trabea A is Madison 617; Lenzites trabea B is Madison 539; Poria monticola A is Madison 698; Poria monticola B is isolate number 94265 (see Table 1).

creosote, copper-8 quinolinolate, phenyl mercuric oleate, and tanalith.

The white-rot fungi with the exception of *Polyporus tulipiferae* showed greater susceptibility to chromated zinc chloride than the brown-rot fungi tested. This preservative was the only one to which similar levels of tolerance were shown by the fungi that cause similar types of rot or belong to the same taxonomic group.

The results confirmed the reported tolerance of *Lentinus lepideus* to creosote (3,8), *Poria monticola, P. incrassata,* and *Fomes subroseus* to copper naphthenate (4,8), *Polyporus tulipiferae* to pentachlorophenol (3), and *Lenzites trabea* to phenyl mercuric oleate (8). *L. trabea* has been reported to be more resistant than *Lentinus lepideus* to pentachlorophenol (8); these results, however, indicated similar levels of resistance for both fungi. *Poria xantha* and *P. vaillantii,* reportedly tolerant to copper naphthenate (3), showed marked susceptibility to this preservative.

Discussion

The results indicate that considerable variation in tolerance to preservative materials exists within and among species of fungi that destroy wood. This variation shows that the isolates and species of fungi used in preservative evaluation tests should be selected on the basis of their tolerance to preservatives as well as for their prevalence in causing decay. Tests with susceptible fungi tend to overestimate the effectiveness of a toxicant. It is therefore desirable to use as test organisms the more tolerant fungi that frequently cause decay. The general resistance to preservatives shown by *Fomes subroseus* as well as its prevalence as a wood-rotting fungus recommend its consideration as a "standard" decay-test organism.

The large number of fungi that showed unusual tolerance to one or more of the preservatives emphasizes the need for information indicating those species which commonly decay various wood products. Selection of the most effective preservative for a given product requires knowledge of the fungi it may be expected to encounter in use, and their respective tolerance patterns. The comprehensive survey of fungi associated with decay in buildings in New York State by Silverborg (7) provides information of a kind greatly needed for other wood products.

The fungi that exhibited unusual tolerance to one or more of the preservatives were invariably susceptible or showed only moderate resistance to at least one, and usually several, of the other preservatives tested. This strongly suggests the potential value of mixtures of chemically compatible materials in controlling a wide range of fungi at lower toxicant concentrations. The possibility of synergism in mixtures, as suggested by the work of Duncan (4), further recommends consideration of mixtures for use as wood preservatives.

The magnitude of the tolerance indexes in Table 3 shows that the concentration of any single preservative must be high to prevent decay by all fungi. This emphasizes the danger of inadequate treatments. Tolerant fungi may cause decay in wood containing sufficient toxicant to control more susceptible organisms.

Screening still more comprehensive lists of fungi for preservative tolerance would provide much useful information. The instances of resistance to preservatives shown by the results, especially those not widely reported, warrant special attention in decay tests and studies of the decay flora of treated wood.

Complete understanding of the phenomenon of resistance to toxicants in fungi requires more than merely determining its incidence and magnitude. Variation in responses to toxic materials reflects physiologic differences among the fungi. Thorough study of these fundamental differences is necessary to explain this important and perplexing aspect of the variability found in biologic populations.

Discussion of the Test Method: The test procedure used in this study provides a simple and rapid laboratory method for determining approximate threshold values. The thresholds are ascertained by visual examination of wood blocks impregnated with preservatives and decayed over a short incubation period. General agreement of the results with those reported by other investigators recommends the method for extensive studies of preservative tolerance. The method would also be useful in screening materials of potential value as preservatives, and as a preliminary range-finding test for thresholds to be more accurately determined by the soil-block test[9]. Where greater precision of threshold determinations is desired, test blocks may be treated "to refusal" by means of the vacuum technique prescribed by Duncan (3).

[9] Duncan (3) has recommended a preliminary test, stating that it insures a closer estimate of the threshold, which is then verified by two independent experiments.

Summary

Threshold values are presented that indicate the comparative tolerance of 18 economically important fungi that decay wood products to ten preservatives of present or potential importance. Fourteen of the fungi showed striking tolerance to one or more of the preservatives. Up to 40 times the amount of preservative needed to control the most susceptible fungi was required to prevent decay by the most tolerant fungi tested. The fungi that showed unusual tolerance to one or more of the preservatives exhibited marked susceptibility to at least one of the other preservatives tested. Separate isolates of *Lenzites trabea* and *Poria monticola* showed substantial differences in resistance to several preservatives. *Fomes subroseus* appeared unusually well qualified for general use as a decay test organism. Implications of variation in preservative tolerance among wood-destroying fungi are discussed in relation to programs of preservative evaluation and decay control and studies of fungal physiology. Recommendations for further research are presented.

The threshold values reported were determined by a modified agar-block decay test procedure. This rapid method is described in detail and suggested as a technique for screening test fungi and potential preservative materials.

Literature Cited

1. Anonymous. 1953. Standard N. W. M. A. methods for testing the preservative property of oil-soluble wood preservatives by using wood specimens uniformly impregnated (NWMA–M–1–53). National Woodwork Manufacturers Association, Inc., Chicago, Ill.
2. ————. 1955. Standards for waterborne preservatives (P5–55). In Manual of Recommended Practice. American Wood–Preservers' Association, Washington, D. C.
3. Duncan, Catherine G. 1953. Soil-block and agar-block techniques for evaluation of oil-type preservatives: creosote, copper naphthenate and pentachlorophenol. Division of Forest Pathology, Bureau of Plant Industry, Forest Products Laboratory, Madison, Wis., Special Release No. 37.
4. ————. 1955. Unpublished manuscript. Forest Products Laboratory, Madison, Wis.
5. Merrick, G. D. 1956. Wood preservation statistics. Amer. Wood-Preservers' Assn. Proc. 52:289–320.
6. Schultz, G. 1954–55. Unpublished manuscript. Forest Products Laboratory, Madison, Wis.
7. Silverborg, S. B. 1953. Fungi associated with the decay of wooden buildings in New York State. Phytopath. 43:20–22.
8. Zabel, R. A. 1954. Variations in preservative tolerance of wood-destroying fungi. Jour. For. Prod. Res. Soc. 4: 166–169.

How and What to Specify in the Preservative Treatment of Wood for Buildings[1]

R. B. PUTMAN

Manager, Wolman Preservative Dept., Wood Preserving Div., Koppers Co., Pittsburgh, Pa.

Wood preserving compounnds and processes of application are discussed in the light of specifications currently applied, standards of technical organizations, and typical requirements for treated wood in buildings.

Introduction

THE DECISION TO USE treated wood in a building is usually made first because the material is remarkably versatile, and, second, when wood is properly treated with a good preservative it can be relied upon for just about as great a degree of permanance as the exposure, the investment, and the rate of obsolescence dictate.

Exposure here means the threat of damage by decay fungi or wood-destroying insects. Wood that is partially buried in damp soil is exposed to severe threat of damage by fungus attack. In certain geographical areas, the same wood also will be liable to attack by termites. In the case of exterior trim, such as window frames, the exposure hazard is relatively moderate, and maintenance of a degree of water repellence combined with a sound paint film, is almost equally as important as the presence of toxic chemicals in the wood.

We speak of treated lumber "protecting the owner's investment". The wood gutter on a house should be treated, but if it is untreated and rots out, it can be replaced when the owner gets around to it; the replacement will not involve a great amount of money. Compare that situation with what would happen if an untreated, non-durable wood species were used in the construction of a flume carrying water to a pulp mill.

"Obsolescence" often means a different process under different circumstances. A mine operator may assign a life of three months to a timber that supports the roof at a coal face, but he may seek 20-year life in main haulageway timber.

When we speak of different wood preservatives and different processes used in applying them as being "heavy-duty" or "light-duty", we do not imply a comparison of intrinsic quality. We simply mean that you can get more or less service life from wood with different types of preservative treatment, depending on how important sheer longevity may be.

Specific requirements such as 1) physical character of the wood after processing, or 2) the rate of obsolescence of the structure to be designed or built will determine the treatment to be used.

There are literally hundreds of wood perservatives on the market today. The majority of those sold in cans for "do-it-yourself" wood treating are more or less identical in composition. It is a fact, however, that architects in the United States recognize and specify at least 30 different names of wood preservatives. It is unfortunate that few of them are aware that there are actually only three classes of preservatives, and within those classes the individual formulas need not be considered as widely different. Although the British wood-preserving industry recognizes 39 different oil-borne and creosote compounds and 15 water-borne formulas, only three or four of the lot are used in treating 85 per cent of their production.

It is not the purpose of this paper, therefore, to consider how deeply we can probe into the field of wood preservatives and wood preserving processes, but to study a simple method of clarification that will enable anyone to write a clear specification that will be understandable to both the lumber supplier and the wood preserver.

By limiting this study to treatments of forest products used in buildings, items such as railroad ties, bridges timbers, poles, fence posts, marine piling, and a number of others that are normally treated can be eliminated. Attention can then be focused on foundation piles, structural lumber, plywood, millwork, and sash and doors.

A good deal of argument has taken place over the past century as to how to get a preservative, good or bad, into the wood. When all the "ifs" and extenuating circumstances" are set aside, the standard pressure process remains as the surest and soundest method. Therefore, when we refer to treated piling or lumber, we mean pressure-treated. Only because of the physical nature of the product and the limited hazard do we make an exception in the case of fine woodwork for residential use.

Wood Preservatives and Treating Processes

There are two primary sources of specifications in this country: the American Wood Preservers' Association (AWPA) and the Federal Supply Service of the General Services Administration of the U. S. Government. Specifications for the treating process are found only in the Standards of the AWPA. Product specifications or chemical analyses, are published as Standards by the AWPA and also are listed in the Federal Standards Stock Catalog. There are minor variations among the product specifications issued by the two agencies, but most of them are of little concern.

There are three classes or types of preservatives that are grouped by the Federal Supply Service and are informally recognized by commercial wood preservers. They are 1) creosote and solutions containing creosote, 2) oil-borne preservatives, and 3) water-borne preservatives.

I. Creosote and Solutions Containing Creosote: This group, classed as heavy oils, includes pure coal tar creosote, creosote-coal tar solutions, and creosote-petroleum solutions. The latter two are dilutions for reasons of economy or physical characteristics. In terms of sheer preservative power over periods of 40 to 50 years, creosote has long ago proved itself. The heavy oils, however, find only limited use in buildings because of their characteristic odor, dark color and oiliness. The

[1] Presented at Session III, Wood Preservation, FPRS 10th National Meeting, June 3-8, Asheville, N. C.

The Author: R. B. Putman graduated from Northwestern University in 1934. He joined the American Lumber and Treating Co. in that year, and was General Sales Manager when the firm merged with Koppers in 1954. He is a member of FPRS, American Wood Preservers Association, and British Wood Preservers Association.

Table 1.—STANDARD SPECIFICATIONS FOR PRESERVATIVES AND SOLVENTS

Preservative	AWPA Spec.	Federal Spec.
Type I (Heavy Oils)		
(a) Coal Tar Creosote	P 1	TT-W-556
(b) Creosote-Coal Tar Solutions	P 2	TT-W-566
(c) Creosote-Petroleum Solution	P 3	TT-W-568
Type II (Oil-Borne Chemicals)		
(a) Pentachlorophenol	P 8	TT-W-570
(b) Copper Naphthenate	P 8	
(c) Petroleum Solvent	P 9	
(d) Water-repellent solvent*		TT-W-572

*Note—The requirements of the National Woodwork Manufacturers' Association for water-repellent preservative solution can be specified as an alternate for pre-treating millwork.

Type III—Water-Borne Chemicals		
(a) Acid Copper Chromate (Celcure)	P 5	TT-W-546
(b) Ammoniacal Copper Arsenite (Chemonite)	P 5	TT-W-549
(c) Chromated Copper-Arsenate (Erdalith)	P 5	TT-W-550
(d) Chromated Zinc Arsenate (Boliden)	P 5	TT-W-538
(e) Chromated Zinc Chloride (CZC)	P 5	TT-W-551
(f) Copperized Chromated Zinc Chloride (CaCZC)	P 5	TT-W-562
(g) Fluor-Chrome-Arsenate-phenol (Wolman)	P 5	TT-W-573

(Names in parentheses are trade marks)

Table 2.—STANDARD PRESERVATIVE RETENTIONS FOR PILING AND LUMBER

Preservative	Recommended Retentions—lbs./cu. ft. A.W.P.A. specification Spec. No.	Standard	Heavy	Federal specification Standard	Heavy
Foundation Piling					
I (a) Creosote	C-3	12		12	
I (b) Creosote-Coal Tar	C-3	12		12	
I (c) Creosote-Petroleum	C-3			14	
Lumber					
I (a) Creosote	C-2	8	10	6	10
I (b) Creosote-Coal Tar	C-2	8	10	6	10
I (c) Creosote-Petroleum	C-2	8	10	7	12
II (a) Pentachlorophenol (5%)	C-2			6	10
II (b) Copper Naphthenate (.75% Copper)	---	---	---	6	10
III (a) Celcure	C-2	0.5	1.0	0.5	0.75
III (b) Chemonite	C-2	0.3	0.5	0.3	0.5
III (c) Erdalith	C-2	0.35	0.75	0.35	0.75
III (d) Boliden Salt	C-2	0.5	1.0	0.5	1.0
III (e) CZC	C-2	0.75	1.0	0.75	1.15
III (f) Copperized CZC	C-2	0.75	1.0	0.75	1.15
III (g) Wolman Salt	C-2	0.35	0.5	0.35	0.55

heavy oils are included here because they are the standard treatment for foundation piles, and are preferred for some specific building elements.

II. **Oil-Borne Preservatives:** Of the various chemicals that are dissolved in non-volatile petroleum carriers, pentachlorophenol and copper naphthenate are the best known and most widely used. Petroleum carriers that meet AWPA specification P–9 are very widely used with pentachlorophenol as the toxic agent, particularly for poles. P–9 heavy oils, referred to in the industry as "pole oils", are relatively dark and viscous, so the treated product is more useful in services where odor and oily surface are not objectionable. These oils are offered as an alternate to creosote.

A P–9 light oil used as a carrier for pentachlorophenol imparts little color to the product, but it still has a tendency to interfere with paint films and to creep along nails into finish materials.

When a volatile solvent is used as the carrier for the toxic chemical, a much cleaner, drier surface results. Such a solution is not covered by an AWPA specification, but Federal Specification TT–W–572 covers a water-repellent preservative and goes into some detail regarding the character of the solvent, the anti-blooming (surface crystallization) agent, and the water-repellant materials.

A variation of the TT–W–572 water-repellent solution is used by manufacturers of woodwork under the standards of the National Woodwork Manuafcturers' Association. For various reasons, principally those associated with vapor pressures, solubility ranges and fiber-fixation, the water-repellent solutions in volatile solvents are not recommended for service where hazards are severe.

III. **Water-Borne Preservatives:** There are more different formulas in this group than there are in both Groups I and II. The physical character of wood treated with water-borne preservative salts is much more uniform, however. All are water-soluble, salts, all but one contain chromium compounds as fixatives or anti-leaching agents, and all are free from odor. The color of the treated wood varies with the formula; that is, copper salts are bluish–green, dinitrophenol (a water-soluble organic salt) is bright yellow, chromates are orange, and so forth.

When properly used, the water-borne salt preservatives give excellent results. They find very wide use in treatment of lumber for light construction, particularly for house construction. When seasoned after treatment to a moisture content below 19 per cent, lumber treated with the water-borne type of preservative will take and hold paint at least as well as untreated wood. Because they are quite odorless, these preservatives are preferred for treatment of lumber to be used in buildings where food, cotton, and other odor sensitive products are stored or processed, or where people congregate, such as in gymnasiums.

For the most part, salt-treated structural lumber is either used "wet from the cylinder" or is air-seasoned at the treating plant or in the dealers' yards. When shrinkage after treatment must be considered, as in the case of matched flooring, the lumber should be seasoned after treatment to the moisture content that it will reach in service.

How to Specify

Taking the word "Specification" as meaning a common point of agreement between buyer and seller, then its seems most logical to turn to the standard specifications that have been developed by, and proved acceptable to, the vast majority of buyers and sellers of pressure-treated wood: those of the American Wood Preservers' Association and the Federal Government. The AWPA Standards are the result of decades of study and testing by the acknowledged experts in the field. In some cases no standard has been established by the AWPA, but the product or process is covered by a Federal specification.

Table 1 classifies preservatives by type, within which are groupings of the compounds that are Standards of the AWPA or acceptable under Federal Specification TT–W–571. Note that TT–W–571 covers "Wood Preservative; Treating Practices", and thus combines classes of compound with processing references. Individual preservatives are designated under specific numbers.

Since the character of an oil-borne preservative is determined both by the kind of chemical and the kind of solvent, it is necessary to provide two references whenever specifying such a solution. Water for water-borne preservatives needs no specification, because local water characteristics of hardness, iron or sulfur content, and so forth, do not affect its use as a solvent.

The amount of chemical injected into wood can be closely controlled by the treating-plant engineer. Thus it is necessary that the specification stipulate the amount of chemical that is to be left in the wood. Most specifications express the retention of preservative in pounds per cubic foot of wood.

The depth to which the preservative penetrates is a very important factor. The deeper and more uniformly the preservative is distributed in the wood, the longer the wood will serve. The concentration of the water-borne salt solution is therefore altered by the treating engineer so as to leave the specified retention of dry chemical distributed to the greatest depth possible.

Such dilution is not practicable in the case of heavy-oil preservatives or oil-borne chemicals, although the so-called "empty-cell" process of treatment is used to accomplish similar results. This simply means that as much preservative is pumped into the wood as is possible, and in subsequent phases of the operation, a large portion of the preservative is recovered. Penetration is achieved, and the treated product is left relatively free of excess preservative. Thus a cleaner job is done and no unnecessary cost is incurred.

Table 2 lists the retentions specified for standard treatment as well as for heavy treatment, and the applicable treating specification of the AWPA. If a specification for treated lumber does not state otherwise, the treating-plant engineers will inject the standard retention. The water-borne salts will be applied by the full-cell process, while the heavy oils and the oil-borne preservatives will be applied by the empty cell process.

Depending on availability in the area where the building is to be constructed, the specification writer can select by name the chemical formula to be used in treating his material. Or, if he has no particular preference and seeks to procure a wide assortment of competitive bids, he can simply ask for quotations on treatment with an oil-borne chemical that meets AWPA Standard P–8, or a water-borne chemical that meets AWPA Standard C–5. In most cases, however, the sales organizations of the various wood-preserving companies will have narrowed his choice down to one or two specific preservatives.

What to Specify

In Table 3 the major classes of buildings have been grouped together, a reference has been made to the requirements peculiar to each group, and the type of treatment most generally specified for each group has been given. To attempt to break these groups down further would be too complicated a task to be dealt with here. The specification writer will not go wrong in following these recommendations, however, because they represent the most popular choices in current practice.

Table 3.—PRESERVATIVE REQUIREMENTS AND RECOMMENDATIONS

Class of Structure or Structural Unit	Expected Hazard	Special Requirements	Specification
Foundation Piling:	Severe decay and termite attack.	Extreme durability	"A"
House Construction:			
Sills, joists, headers, posts, girders, briding, first-floor sub-flooring, sleepers and nailers; porch steps, framing, flooring, column bases.	Decay and termite attack.	Freedom from odor, absence of bleeding.	"B" or "D"
Window sash and frames, exterior doors and trim.	Moderate decay attack.	Paintability dimensional stability.	"C"
Wet Process Industries (Pulp and paper, textile dyeing and finishing, laundries, soaperies, etc.):			
Roof trusses, roof decking, sub-flooring, sash and frames, ventilators, etc.	Decay attack.	Paintability	"D"
Humidified Buildings (Weave rooms, printing plants, tobacco seasoning rooms, ripening rooms, etc.):			
Roof decking, sub-flooring, sash and frames.	Decay attack.	Paintability	"D"
Refrigerated Structures (Ice storages, cold storages, locker plants):			
Framing, flooring, ceiling, roof decking.	Decay and termite attack.	Paintability, freedom from odor.	"D"
General Building Construction (Schools, hospitals, commercial buildings, etc.):			
Sleepers in concrete, furring strips, nailers, door and window bucks in exterior concrete or masonry walls, etc.	Decay and termite attack.	Freedom from odor, absence of bleeding.	"D"

SPECIFICATIONS

"A" Pressure treatment with AWPA Grade One Creosote in accordance with AWPA Standard C-3 to a net retention of 12 pounds per cubic foot.

"B" Pressure treatment with (Type II*) preservative, light petroleum solvent meeting AWPA Standard P-9, to a net retention of 6 pounds per cubic foot.

"C" Treatment with water-repellent solution of pentachlorophenol in accordance with the Standards of the National Woodwork Manufacturers Association for preservative and application.

"D" Pressure treatment with (Type III*) preservative, AWPA Standard C-5, in accordance with AWPA Standard C-2, to a net retention of (Standard) pound per cubic foot.

*Insert preferred preservative name. See Table 1 for choices.

Discussion

J. D. Taylor (Greenville Wood Preserving Co.): Do all these salts corrode hardware? We should be able to know this so users can be told about those that will and those that will not.

Mr. Putman: Preservative salts range from quite corrosive to non-corrosive. Differences in standards should be argued out by producers and suppliers. If corrosive effect is to be included it should be by action of producers and suppliers.

Mr. Taylor: Commercial specifications should cover corrosive qualities of preservatives.

Anon.: With water borne salts the object is to preserve wood. Suppliers cannot stock more than 2 or 3 preservatives and producers and suppliers could give the retailer characteristics of preservatives.

G. G. Garlick: I feel that we need to give more study to the other methods of treating for building construction, as most of our data given is regarding pressure treatment.

For the past 20 years lumber dealers and suppliers have been soaking lumber in water repellent preservative treatments, and the results in the field have been gratifying. Also, there are a number of firms today operating vacuum tanks capable of doing a very adequate job of treating lumber for building construction.

Most research that has been carried out in regard to preservatives on wood has been on stakes or posts in the ground, and here the exposure is extremely severe. However, in building construction where the wood is not in contact with the ground the exposure is entirely different, and a good water repellent preservative can do an excellent job with fairly light retentions.

Many builders, contractors and architects rely upon lumber treated with a water repellent preservative, by the soak or vacuum method, and today there are in the neighborhood of 500 firms doing this type of treating. We as a society need to look into this phase of treating and recognize there are many places where it can be used in building construction to protect the lumber at a reasonable cost, and by a method or methods that are easily available to the lumber dealer or even on a site of construction.

An Accelerated Wood-Preservative Termite Study[1]

ANDERS E. LUND
School of Forestry, Duke University
Durham, North Carolina

A method is described that uses varying preservative retentions to determine the approximate threshold killing concentration for subterranean termites. Laboratory results with southern yellow pine sapwood specimens treated with three water-borne preservatives are presented.

Introduction

DURING THE DEVELOPMENT of our country, much of the wood used was naturally durable and somewhat resistant to termites. As second-growth timber became predominant, however, the amount of sapwood used increased; consequently there has been a great increase in termite damage.

At the present time, termite activity in buildings constructed with untreated lumber is widespread and the cost of the damage is tremendous (1, 4, 8, 10).[2]

The use of treated lumber for all sub-structure building members is an effective means of combatting subterranean termites. Pressure treatment is the most effective method of treating these wooden members with preservatives (9, 13). Numerous service records are available for treated wood, but fungus decay and termite damage are usually combined when reported (5, 6, 7). Reports are available listing retentions that give adequate protection against termites (2, 3).

A great deal of experimental laboratory and field work has been done in obtaining the percentage of various preservatives needed to inhibit and to kill numerous fungi, but there has been a lack of data presented on the threshold killing concentration for termites.

This study was initiated with the main objective of obtaining, if possible, the retentions of various water-borne preservatives necessary to kill subterranean termites. A secondary objective was the development of a laboratory testing method for future investigations of wood preservative/termite relationships.

[1] 1957 Wood Award Entry.
[2] Numbers in parentheses refer to literature cited.

The Author: Anders Lund holds a B.S.F. from Colorado A.&M., and a M.F. from Duke University. A member of FPRS, AWPA, and SAF, he received a National Lumber Manufacturers Scholarship in 1956 with 10 weeks on-the-job training at Timber Engineering Company Research Laboratory.

Procedure

Fifty ¾- by ¾- by 2-inch sample sections were cut from a flat-sawn, all sapwood, kiln-dried, southern yellow pine board. The sections were cut in a lengthwise pattern from the clear board and grouped in matched pairs. That is, the two blocks in a pair came from adjacent lengthwise positions so that they were matched up and down the tree and not across the bole. Each block was given an identifying number. The sections were oven dried at 103° C. until of constant weight, and then five pairs (ten sections) were selected at random and specific gravity calculations were made on them. Wood volumes were determined for the remaining 40 oven-dry test blocks.

Five concentrations of each of the following wood preserving compounds were made: copperized chromated zinc chloride, Wolman salt (Tanalith), and Boliden salt (American Wood–Preservers' Association Standard P-5). The concentrations, based on per cent dry weight of compound in distilled water, were as follows: 0.25, 0.50, 1.00, 2.00, and 4.00. Approximately 500 ml of each concentration for each preservative was placed in an open container, and then a matched pair of wood sections, randomly selected, was submerged in each solution. Each matched pair of controls was submerged in a container of distilled water. The containers were placed in an experimental treating cylinder, and a pressure of 200 psi was applied for two hours. The ambient temperature and the temperature of the solutions were approximately 85° F.

Upon removal from the cylinder, the wood sections were allowed to drain until drip-free and then were weighed to determine preservative pickup. After the sections were weighed, they were placed in a forced-air circulating humidity chamber for 11 days at a dry-bulb temperature of 85° F. and a wet-bulb temperature of 82° F., which indicates a relative humidity of 88 per cent. The resulting equilibrium moisture content was about 19 per cent when the blocks reached constant weight. Moisture content and oven-dry weight, corrected for preservative pickup, were calculated.

The termites used were not identified as to species, but they were of the Reticulitermes genus (subterranean type) collected near Durham, N.C. The wood containing the termites was taken to the laboratory, where the termites were removed. The termites were kept for approximately 14 hours between damp paper toweling, which helped to separate the less vigorous and injured termites from the others. Only the more vigorous individuals were used.

The soil used was of a loamy-sand type potting soil, screened to remove excess humus. After it was thoroughly mixed, the moisture equivalent (field capacity) and pH were measured.

The conditioned wood blocks were placed in 3-ounce glass jars and were identified by number, with one side of the block adjacent to the glass to facilitate making observations of the termite activity. Only one block was placed in each jar. In conducting fungal studies it is a common practice to place treated and untreated blocks together within the same container (12), but this method is not practical with termites because they would select for attack only the untreated blocks.

Each block was buried in the loamy-sand soil, which was at its moisture equivalent. This provided sufficient moisture for the termites. A paper funnel with an outlet about the same size as the jar opening was inserted into the jar. Then the damp paper towels, to which termites were clinging, were gently shaken into the funnel to dislodge the termites. To reduce handling and excessive injury, the termites were neither counted individually nor measured volumetrically as is sometimes done, but were added to each jar until the top of the soil was covered so that no soil was visible. In two instances, visual counts were made. Approximately 200 termites were counted in each of these instances.

Table 1.—TREATING AND TERMITE TEST DATA ON 40 EXPERIMENTAL PINE BLOCKS

Block No.	Treatment	Treating solution, per cent	Dry salt retention, lbs/ft³	Retention per pair, lbs/ft³	Visual evidence of attack	Weight loss, per cent*	Weight loss, per cent†
1	CCZC	0.25	0.0619	0.0612	Yes	1.75	2.20
2	CCZC	0.25	0.0606		No	1.48	1.98
3	CCZC	0.50	0.1192	0.1209	Yes	1.52	2.02
4	CCZC	0.50	0.1226		No	2.06	2.59
5	CCZC	1.00	0.2245	0.2261	Yes	1.67	2.01
6	CCZC	1.00	0.2276		Yes	1.98	2.07
7	CCZC	2.00	0.4545	0.4592	Yes	2.34	2.58
8	CCZC	2.00	0.4639		Yes	1.86	2.13
9	CCZC	4.00	1.0200	1.0221	No	2.59	2.71
10	CCZC	4.00	1.0241		No	2.94	3.10
					Average Loss	2.02	2.34
11	Wolman Salt	0.25	0.0573	0.0573	No	0.85	2.24
12	Wolman Salt	0.25	0.0573		Yes	1.89	1.57
13	Wolman Salt	0.50	0.1233	0.1198	No	1.28	1.96
14	Wolman Salt	0.50	0.1162		No	1.18	1.84
15	Wolman Salt	1.00	0.2459	0.2504	No	1.42	1.70
16	Wolman Salt	1.00	0.2550		No	1.30	2.00
17	Wolman Salt	2.00	0.5290	0.4938	No	1.82	2.44
18	Wolman Salt	2.00	0.4585		No	1.15	2.63
19	Wolman Salt	4.00	1.0281	1.0756	No	2.34	2.64
20	Wolman Salt	4.00	1.1230		No	2.58	2.77
					Average Loss	1.64	2.18
21	Boliden Salt	0.25	0.0610	0.0610	No	0.78	2.18
22	Boliden Salt	0.25	0.0610		Yes	1.98	1.77
23	Boliden Salt	0.50	0.1260	0.1189	No	1.42	2.29
24	Boliden Salt	0.50	0.1118		No	1.84	2.42
25	Boliden Salt	1.00	0.2425	0.2514	No	0.99	2.68
26	Boliden Salt	1.00	0.2604		No	0.60	2.72
27	Boliden Salt	2.00	0.5012	0.4663	No	0.60	2.46
28	Boliden Salt	2.00	0.4314		No	1.66	3.00
29	Boliden Salt	4.00	1.0755	1.0836	No	1.56	2.89
30	Boliden Salt	4.00	1.0918		No	1.64	3.12
					Average Loss	1.31	2.55
31	Control				Yes	3.88	5.06
32	Control				Yes	2.64	3.91
33	Control				Yes	4.02	5.20
34	Control				Yes	2.81	4.68
35	Control				Yes	5.00	6.34
36	Control				Yes	3.79	5.82
37	Control				Yes	4.90	3.35
38	Control				Yes	3.98	2.99
39	Control				Yes	6.04	4.72
40	Control				Yes	5.13	4.17
					Average Loss	4.22	4.62

*Based on 19 per cent wood moisture content.
†On an oven-dry basis.

Termites were selected randomly for inclusion in any particular jar. After the termites were added, the jars were weighed and then placed in a circulating-air, constant-temperature, insect-rearing chamber controlled at 30± 1° C. Increased humidity was provided by directing the circulating fan so that the air was blown across a tray containing water. Relative humidity averaged 62 per cent throughout the study. Every second day each jar was reweighed and, if necessary, a few drops of distilled water were added to keep the weight constant and the soil at field capacity. When the jars were weighed, they were inspected for termite activity and for any unusual appearances.

After 40 days, the blocks were removed from the containers and allowed to air dry for 48 hours to remove surface moisture. Each block was brushed to remove soil particles and then observed for evidence of termite attack. The destroyed areas were measured and the volumes computed. After examination, the sections were rinsed in cool distilled water to remove any remaining soil particles. Photographs were taken of all blocks that showed visible evidence of attack.

The wood sections were then placed in a forced-air circulating humidity chamber operated at the same conditions as those used at the beginning of the experiment. After 11 days, the blocks, at constant weight, were removed and reweighed to determine weight loss. This loss could be due to both termite activity and possible leaching. The results are presented in Table 1.

The number of rings per inch for each pair of blocks was measured on the cross-sectional face, and the per cent summerwood was computed on the radial face. As a further check, the sample blocks were then redried to constant weight at 103° C. and reweighed to determine the weight loss on an oven-dry basis. After drying, each block was severed at the midpoint for preservative penetration tests. For checking Boliden Salt and Wolman Salt penetration, the following solutions were used: 1) aqueous solution of ammonium molybdate in concentrated nitric acid; 2) aqueous solution of benzidine in concentrated acetic acid; and 3) aqueous solution of stannous chloride in concentrated hydrochloric acid. The method of applying the solutions and interperting the results was that used by the preservative distributers or manufacturers and is outlined in the American Wood-Preservers' Manual of Recommended Practice, Section A3–55. For checking the penetration of copperized chromated zinc chloride, the following solutions were used: 1) aqueous solution of potassium ferricyanide 2) Starch Indicator solution; and 3) aqueous solution of potassium iodide. These solutions were also applied as outlined in section A3–55.

Results

Physical examination of the blocks revealed a range in the per cent of summerwood of from 47.8 to 50.5, and an average of 6 rings per inch. Moisture content varied from 18.3 to 20.2 per cent, while specific gravity was calculated as 0.508 based on a sample of ten blocks.

The soil used in this study had a pH of 6.0. This pH is common for slightly acid, humid-region mineral soils. The moisture equivalent (field capacity) was 11.4 per cent. The soil belonged to the sand class and specifically to the loamy sands.

In treating the pine blocks with

Table 2.—VOLUME AND PER CENT OF DESTROYED PORTION OF THE PINE BLOCKS WITH VISIBLE EVIDENCE OF ATTACK

Block No.	Preservative	Retentions, lbs/ft³	Volume of destroyed portion, mm³	Destroyed volume, per cent
1	CCZC	0.062	27.25	0.148
3	CCZC	0.119	4.62	0.025
5	CCZC	0.224	7.00	0.038
6	CCZC	0.228	4.75	0.026
7	CCZC	0.455	2.00	0.011
8	CCZC	0.464	4.00	0.022
			Average 8.27	0.045
12	Wolman Salt	0.057	5.25	0.028
			Average 5.25	0.028
22	Boliden Salt	0.061	2.50	0.014
			Average 2.50	0.014
31	Untreated (Control)		407.00	2.21
32	Untreated (Control)		415.00	2.25
33	Untreated (Control)		648.00	3.52
34	Untreated (Control)		471.00	2.56
35	Untreated (Control)		1098.00	5.96
36	Untreated (Control)		863.50	4.63
37	Untreated (Control)		566.00	3.07
38	Untreated (Control)		241.00	1.31
39	Untreated (Control)		630.00	3.42
40	Untreated (Control)		545.00	2.96
			Average 587.45	3.19

the various preservatives, five solution concentrations for each preservative were used. The purpose of varying the concentrations was to obtain a range of retentions of the preservatives. The desired retentions were: 1.00 lb., 0.50 lb., 0.25 lb., 0.125 lb., and 0.062 pound per cubic foot. In all cases, the 4 per cent solution gave dry salt retentions of one pound or over. The 2 per cent solution gave an average retention of slightly less than 0.50 pound; the 1 per cent solution gave an average retention of from slightly more than 0.25 lb. to slightly less; the 0.5 per cent solution gave an average of slightly less than 0.125 lb. and the 0.25 per cent solution gave an average retention of slightly less than 0.062 lb. Table 1 presents these treating and retention data.

At the termination of the experiment, visible evidence of termite attack was found on 18 of the 40 block specimens. All ten untreated (control) blocks showed evidence of attack. For the treated blocks, six copperized chromated zinc chloride, one Boliden Salt, and one Wolman Salt block showed evidence of attack. Of the copperized CZC treated blocks, one with a retention of 0.062 lb. per cu. ft. was attacked, and one with 0.125 lb. of preservative per cu. ft. was attacked. Both blocks with 0.25 lb. retention as well as both blocks with 0.50 lb. retention showed evidence of attack.

For the blocks treated with Wolman Salt (Tanalith), the one specimen attacked had a preservative retention of 0.062 lb. per cu ft.

Among the blocks treated with Boliden salt, the one exhibiting evidence of attack had a retention of 0.062 lb. per cu. ft.

Measured loss in wood volume ranged from 2.5 cubic millimeters (0.01 per cent) for the Boliden Salt block to 1098 cu. mm. (5.96 per cent) for the control block attacked most heavily. Table 2 contains the volume losses. Measurements of destroyed wood, of course, were not extremely precise. These data indicate that the untreated blocks lost approximately 82 times more wood volume than did the treated blocks. Photographs of these blocks are presented in Figs. 1 to 4. The blocks in the photographs are identified by the same numbers as used in the tables. In the pictures of the untreated blocks (Figs. 3 and 4), the sides shown are those most severely injured. These blocks were also attacked on the end faces. The attacked treated blocks are shown in Figs. 1 and 2. The side pictured is the only face showing evidence of attack.

In all cases, the termite activity was limited to the softer (springwood) portion of the annual ring. The springwood shows up as the lighter colored portion of the annual ring in the photographs. A graphic presentation showing the relationship between loss in wood and preservative retention for each attacked treated block is presented in Fig. 5.

Fig. 1.—Pine blocks treated with copperized chromated zinc chloride, showing visible evidence of termite attack. Retentions given in Table 2.

After the blocks had been reconditioned to 19 per cent moisture content, they were reweighed and the weights were compared with those obtained at the beginning of the tests. The weight loss, expressed in per cent based on a 19 per cent wood moisture content, is given in Table 1. For the blocks treated with copperized chromated zinc chloride, there was no appreciable difference in weight loss of the block within a pair with visible evidence of attack, compared to the block, within the same pair, with no visible evidence of termite attack. Conversely, in both the Wolmanized- and the Boliden Salt-treated blocks, there is a significant difference between the attacked block and the paired block with no visible attack. Between the average weight loss for the treated blocks and the untreated control blocks there is an appreciable difference, which amounts to about 154 per cent greater loss in the untreated blocks. A graphic presentation of these data are presented in Fig. 8.

Each block was oven-dried at 103° C. until it reached constant weight, and it was then compared with the

Fig. 2.—Pine blocks treated with Wolman Salt (No. 12) and Boliden Salt (No. 22), showing visible evidence of termite attack. Retentions given in Table 2.

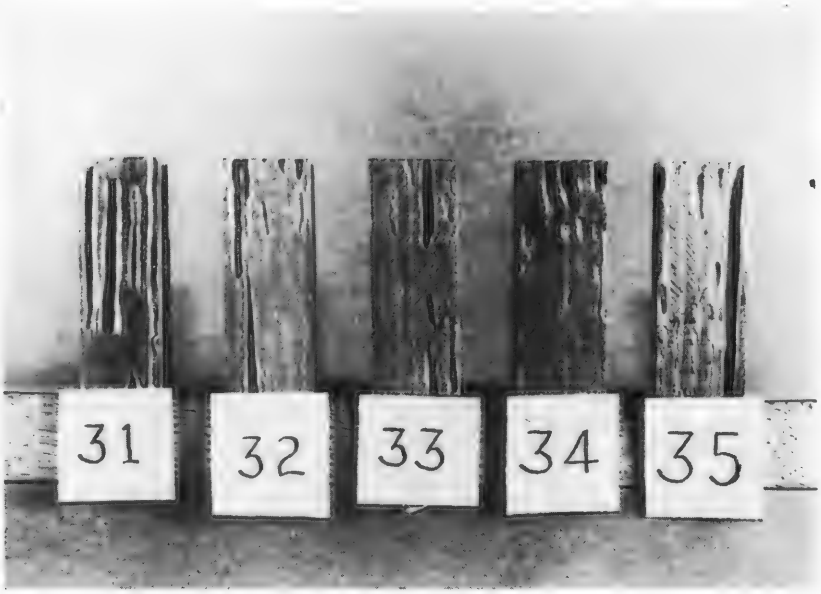


Fig. 3.—Untreated southern yellow pine blocks, showing visible evidence of subterranean termite attack.

original oven-dry weight, corrected for preservative retention. The per cent loss on an oven-dry basis for each block is given in Table 1 and is presented graphically in Fig. 9. In the copperized CZC-treated blocks there is no significant difference between the weight loss of the unattacked treated block versus the attacked treated block of each pair. For the Wolmanized blocks, however, there is a negative difference in the weight loss between the attacked and non-attacked blocks of the same pair. There is no appreciable difference between the attacked and the non-attacked blocks for the Boliden Salt-treated blocks.

Between the average weight loss for the untreated and the treated blocks there is an approximate difference of about a 97 per cent increase in the weight lost in the control blocks. This is compared to the 154 per cent loss increase when calculated on a 19 per cent moisture content basis.

After the data for calculating weight loss on an oven-dry basis were obtained, each treated block was cut in half to determine preservative penetration. With the small specimens used, complete penetration was virtually assured although the color indicators showed poor penetration at the lower retentions. In the Boliden Salt-treated blocks, the retention of 0.062 lb. gave a color reaction that showed spotty penetration. The Wolmanized blocks with the 0.062 lb. retentions exhibited no definite interior penetration.

The copperized CZC-treated blocks with a 0.062 lb. retention showed a uniform penetration on block No. 1

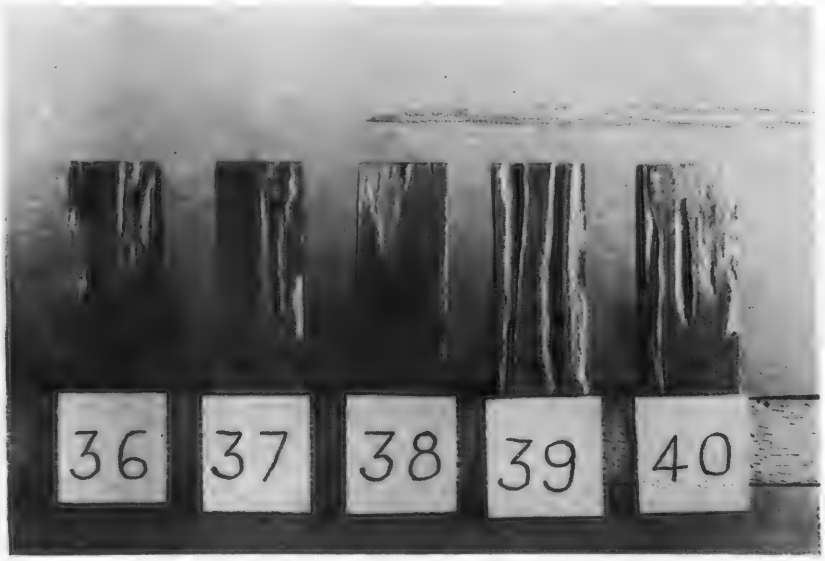


Fig. 4.—Untreated southern yellow pine blocks, showing visible evidence of subterranean termite attack.

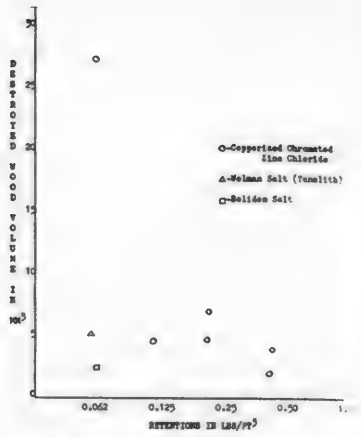


Fig. 5.—Relationship between loss in wood volume and preservative retention. Each symbol represents one block.

and a spotty penetration on block No. 2.

Although the indicator used for Wolman and Boliden Salts is described as being sensitive to arsenic, it was felt that the 0.062 lb. per cu. ft. retention coupled with the amount of arsenic in the preservatives wasn't sufficient to cause the color change indicating penetration.

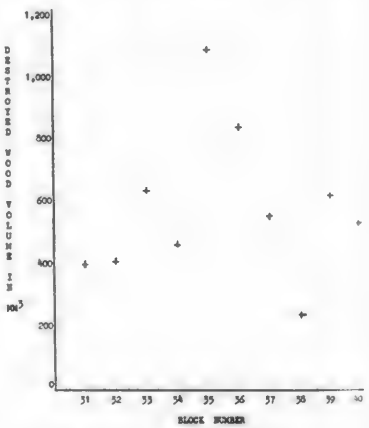


Fig. 6.—Loss in wood volume of untreated pine blocks.

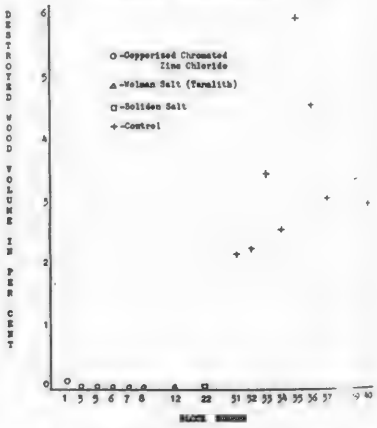


Fig. 7.—Loss in volume of treated and untreated pine blocks with visible evidence of termite attack.

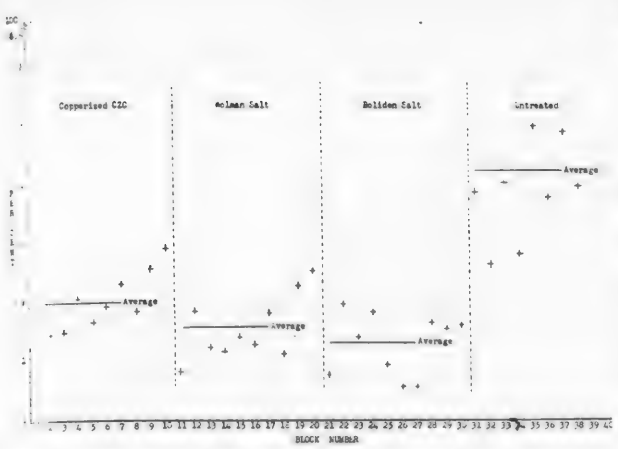


Fig. 8.—Weight loss, in per cent, of 40 southern yellow pine blocks on a 19 per cent moisture content basis.

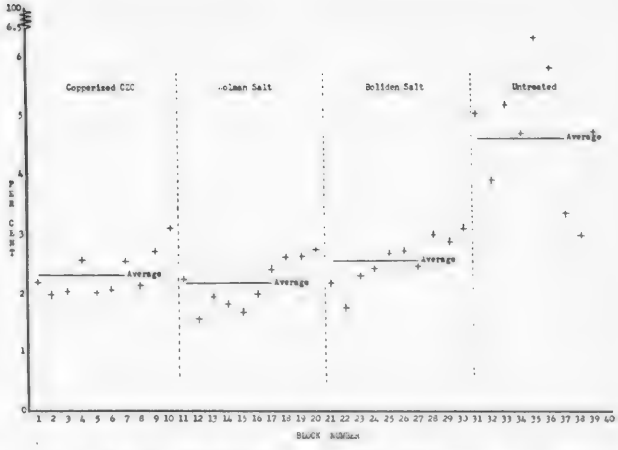


Fig. 9.—Weight loss, in per cent, of 40 southern yellow pine blocks on an oven-dry basis.

At the end of the experiment, no wood rot was exhibited in any of the test blocks.

Cannibalism among the termites, although reported as common in laboratory colonies (14), was not observed at any time during this study.

An important problem that developed during the project was the death of a majority of the termites throughout a number of the containers. During the first 14 days of the experiment, vigorous termite activity was noted in all 40 jars containing the blocks. From the 14th to the 20th day, visible activity ceased in all jars containing blocks treated with Boliden Salt and in all except one of the jars containing blocks treated with Wolman Salt. Visible activity ceased in the jars containing copperized CZC blocks treated to a retention of 1.00 lb. per cu. ft. during the same period. Vigorous activity was observed in all jars containing untreated blocks during this time. A few days later, very little activity was noted in the remaining jars, and at the end of 40 days when the study was terminated, visible activity was noted only in jars containing block Nos. 1, 35, 36. As the blocks were removed from the jars this was confirmed, since live termites were found only in these jars. Less than 20 live termites were found in the jar containing block No. 1 and less than 50 in the jars containing block Nos. 35 and 36. In comparing this to the weight and volume loss data, there appears to be no correlation.

In the present study, a majority of the termites, including controls, died before the experiment terminated. There are a number of possible causes for the more or less uniform death of the termites. A carbon dioxide content too high for termite survival may have been caused by lack of dissipation from the small containers. This carbon dioxide buildup would reduce the oxygen pressure and also the amount of oxygen available to the termites. A definite oxygen pressure may be necessary for survival of subterranean termites (11).

The mortality may possibly have been the result of unnatural environmental conditions that were more or less uniform throughout the test containers. The observed mortality did not begin until after a length of time that would permit termite attack of the blocks. The results presented are therefore only partially influenced by this factor, and the influence is limited to its affect on the degree of wood volume loss and not the relationship between retentions and attack.

Summary and Conclusions

In laboratory tests, all sapwood southern yellow pine blocks treated with Wolman Salt and Boliden Salt and then buried in moist soil were immune to subterranean termite attack. The range in retention of dry salt in the blocks was 1.00, 0.50, 0.25, and 0.125 lb. per cu. ft.

In one block containing each preservative, treated to a retention of 0.062 lb. of dry salt per cubic foot, there was visible evidence of attack.

Blocks treated with copperized chromated zinc chloride to a retention of 1.00 lb. per cu. ft. were immune to attack. Visible evidence of attack was noted on blocks treated to the following retentions: 0.50, 0.25, 0.125 and 0.062 lb. per cu. ft.

The data obtained under the conditions outlined in this study suggests that the threshold killing concentration for the species of subterranean termites used may be approximately 0.062 lb. per cu. ft. for Boliden Salt and Wolman Salt, and approximately 0.50 lb. per cu. ft. for copperized CZC. In evaluating termite attack, the loss in wood volume appeared to be a more significant measure than the weight loss.

Literature Cited

1. Anon. ———— 1955. Wood handbook. USDA Handbook No. 72: 389–90. Washington.
2. Anon. op. cit.: 407–9.
3. Anon. ———— 1950. Federal Specification TT-W571c.
4. Anon. ———— 1956. Why CZC treated lumber is necessary. Brochure A09570, duPont de Nemours, Wilmington.
5. Blew, J. O. & Kulp, J. 1955. Comparisons of Wood Preservatives in Mississippi Post Study, Forest Products Laboratory, Report 1757.
6. Blew, J. O. 1953. Comparison of Wood Preservatives in Stake Tests. Forest Products Laboratory Report 1761.
7. Blew, J. O. & Kulp, J. 1954. Service Records on Treated and Untreated Fence Posts, Forest Products Laboratory Report 2005.
8. Anon. ———— 1957. How to build homes that will outlive the mortgage. American Wood Preservers' Institute, Chicago.
9. Blew, J. O. 1956. "Study of preservative treatment of lumber". American Wood-Preservers' Proceedings, Vol. 52, p. 78.
10. Graham, S. A. 1952. Forest entomology: 9, 297. McGraw-Hill, New York.
11. Hunt and Garratt 1953. Wood preservation: 51, McGraw–Hill, New York. York.
12. Hunt and Garratt op. cit. 78–79.
13. MacLean, J. D. 1952. Preservative treatment of wood by pressure methods, USDA Handbook 40:2, Washington.
14. Snyder, T. E. 1948. Our enemy the termite: 101, Ed. 2, Comstock, Ithaca.

High-Temperature Drying of British Columbia Softwoods[1,2]

F. W. GUERNSEY

Head of Utilization Section, Vancouver Laboratory, Forest Products Laboratories of Canada

Speed and less space are among the advantages of high-temperature drying. Little is known of the effect on the wood itself, however. There is a tendency for wood to darken slightly, but nothing conclusive is known about strength values.

Introduction

DRYING LUMBER AT TEMPERATURES above the boiling point of water is not a new process. In 1867, a patent was granted in the United States for "Apparatus for Drying and Seasoning Lumber by Superheated Steam". Tiemann[3] described in 1917 the experimental work he carried on with his associates on the drying of lumber by superheated steam. In 1918, Tiemann was granted a patent for his superheated-steam kiln, and it is reported that in the same year several of these kilns were in operation on the west coast. Very little has been heard of these kilns since that time, however.

The use of temperatures about 212° F. for drying wood was revived in Germany during World War II, and German investigators were instrumental in creating interest in this form of kiln-drying in Europe, the United States, and Canada.

There are two processes of high temperature drying. The first, developed by Tiemann and other experimenters, uses superheated steam. That is, steam above the boiling point of water. In this system, the steam occupies the kiln to the complete exclusion of air. The steam can give up its superheat without condensing and thus act as a drying agent. Since there is no air present, relative humidity relationships are not applicable and temperature is the only control possible. Superheated steam, like air, requires circulation to carry its heat to the lumber.

A mixture of air and steam is used in the other process. This process was developed by German technologists and is the one being used by the Ottawa and Vancouver laboratories. It resembles the conventional type of drying in that both wet and dry bulbs are used for control, and different degrees of saturation are possible.

In 1952, a small pilot kiln was loaned to the Ottawa laboratory by a German manufacturer, and preliminary investigations were started on eastern wood species. Two runs each were also made on Douglas-fir, western hemlock, and western red cedar. This kiln was of a semi-commercial type, all metal construction. It held 500 ft.b.m. of lumber, was electrically heated, and had a steam line for humidification. There was a thermostat to control temperature, but no means of controlling humidity was included, although the rate at which the humidity fell could be controlled, to a certain extent, by the intake and outlet dampers.

Ladell[4] reports that, in general, the quality of the dried lumber was very good. The extremely rapid drying, however, caused severe casehardening. Very little checking—either end or surface—resulted, and the knots remained firm although some splitting of tight knots was observed in hemlock and Douglas-fir. Twisting, bowing, cupping, and crook were negligible. The material milled satisfactorily and there was slight discoloration. A charge of white pine was dried and there was no trace of chemical brown stain, possibly because of the relatively short period during which the lumber was under conditions of high temperature and relative humidity.

Variation in moisture content, both in individual boards and throughout the charges, was considerable, but conditioning treatments carried out on subsequent charges materially reduced this variation. Some of the data obtained are listed in Table 1.

After the results had been thoroughly analyzed, it was apparent that this kiln was not satisfactory for experimental work and that certain important factors could not be evaluated until new equipment became available. A new kiln embodying many improvements, including reversible circulation, was designed and built at the Ottawa laboratory. Recent tests in this new kiln have shown that variations in moisture content can be largely eliminated by using a sufficiently high circulation rate (500 ft./min.) and reversing the circulation at regular intervals.

In view of the large number of species and sizes that need to be tested in Canada, it was decided to design and construct an additional small, high-temperature experimental unit at the Vancouver laboratory.

[1] A contribution from the Forest Products Laboratories of Canada, Forestry Branch, Department of Northern Affairs and Natural Resources.

[2] Presented at the Northwest Region Meeting, Sept. 24–25, 1956, Lewiston, Idaho.

[3] Tiemann, H. D. 1917. The kiln drying of Lumber, J. A. Lippincott Co.

The Author: F. W. Guernsey received a B.A.Sc degree in forestry from the University of British Columbia. He is now head of the Utilization Section of the Vancouver laboratory, where he specializes in lumber seasoning and utilization.

[4] Ladell, J. L., Mimeo. 0–170, High Temperature Kiln-drying of Canadian Woods. Dept. of Northern Affairs and National Resources. Forestry Branch, Forest Products Laboratories Division, Ottawa.

Table 1.—DRYING TESTS—WESTERN SPECIES

Run No.	Species	Thickness	Average drying temp.*	Air-vent settings		Average moisture content		Warming up period		Drying time		Cooling period		Conditioning period		Total time		Average drying rate† MC
				Intake	Exhaust	Initial	Final											
		in.	°F			MC—%	MC—%	hr.	min.	hr.	min.	hr.	min.	hr.	min.	hr.	min.	hr.
1	Western hemlock	1	237	1/3 open	wide open	75.2	5.2	2	29	25	26	4	10	0	44	32	49	.8
2	Western hemlock	2	237	1/3 open	wide open	56.4	7.0	3	01	45	59	5	09	1	00	55	09	.1
3	Douglas fir	1	235	1/3 open	wide open	47.3	8.2	4	03	17	31	5	56	0	40	28	10	.2
4	Douglas fir	2	237	1/3 open	wide open	41.2	7.2	2	40	34	55	5	53	1	01	44	29	1.0
5	W. R. cedar	1	234	1/3 open	wide open	45.4	6.6	1	44	24	11	6	05	0	45	32	45	.6
6	W. R. cedar	2	235	1/3 open	wide open	36.1	12.5	2	38	28	32	5	50	nil		37	00	.8

*Drying temperatures were maintained at approximately 230° F. for most of run, and were increased to approximately 250° F. when charge was below the fiber saturation point.

†During drying period only.

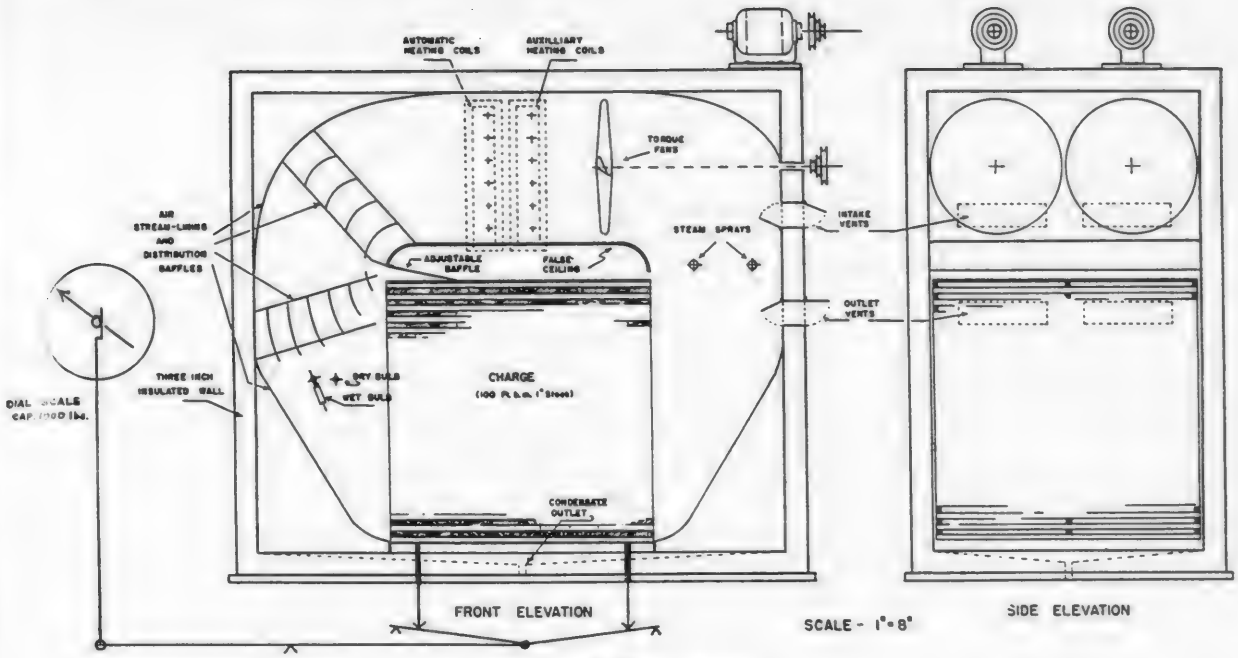


Fig. 1.—Experimental dry kiln.

This paper provides a brief description of the latter kiln, the method of operation, and some of the findings that have been observed to date.

Description of Equipment

Restrictions of space at the laboratory limited the size of the unit so that, compared with a commercial installation, it is relatively small. It holds approximately 100 ft.b.m. of 1-inch lumber. For experimental work, however, this is somewhat of an advantage, since matched charges can be dried under different schedules simply by cutting long boards into lengths suitable for the kiln.

The chamber is constructed of sheet aluminum, and is insulated with glass wool. The joints of the inner walls are welded so that no moisture can escape into the insulation. Drains are provided in the floor to carry away condensed moisture. Circulation is provided by two aluminum 18-inch propeller-type fans above a false ceiling. The speed of these fans can be varied to give air velocities through the load of between 400 and 1100 feet per minute. One fan revolves clockwise and the other counter-clockwise to eliminate spiraling circulation, and thus provide a uniform flow of air across the kiln. Automatic air outlets and inlets are provided. Heating is by electrical coils automatically controlled by the recording instrument, although provision is made to heat the installation by steam coils if necessary. Humidity during the run is provided by an immersion heater. During the warming up period, however, live steam from a boiler is used for this purpose.

The recorder-controller instrument has a range of 80° F. to 300° F. There are wet and dry bulbs on the incoming air side, which record and control, while a third bulb on the outgoing air side records only and may be used as a wet or dry bulb.

Doors and dampers have silicone rubber gaskets to make them vaporproof. Silicone rubber has been found to retain its resiliency at high temperatures, and so far has remained soft and pliable even though the kiln has been in use for eight months.

Recently a platform sacle was installed. This scale weighs the whole load in the kiln so that the rate of drying and the moisture content can be determined at any stage of the drying period. This gives better control of the final moisture content[3] since it is not possible to use test boards in the kiln without upsetting the drying conditions. These installations are diagrammed in Fig. 1.

Lumber is piled in the kiln in the usual manner, and the weight is recorded. Moisture content determinations are made by cutting sections from a selected number of boards. The oven-dry weight of the load is therefore determined and the weight at 8 per cent is calculated, and when the load reaches this predetermined weight the heat is turned off.

Warming up is accomplished by injecting live steam into the kiln. This was found to be the best and quickest method of heating the lumber thoroughly. When the temperature reaches 212°, the controller is set to the temperature required and the run is on its way. The live steam is then turned off. The moisture evaporated from the lumber, with the addition of vapor from a small immersion heater, keeps the wet bulb at the required setting.

When the moisture content of the load, determined by the weight, reaches 8 per cent, the heat is turned off and the dry bulb is allowed to drop to the wet bulb setting. This is equivalent to conditioning, and it has been found that casehardening is almost eliminated by this procedure.

When the wet and dry bulb temperature are at the same reading, the immersion heater is turned off and the whole charge is allowed to cool to 100° F. It was found that if the charge was removed at elevated temperatures, severe end and surface checking occurred.

Results and Discussion

The results of two series of kiln runs, one western hemlock and one Douglas-fir, are shown in Tables 2 and 3. Kiln checks were assessed as slight, medium, and severe. Slight checks ranged from almost invisible hair checks to visible checks that would completely surface out on machining. Medium checks consisted of those appearing as fine checks after dressing that might degrade the piece, and through checks and splits were classified as severe checks. Considering the harsh conditions in the kiln, the degrade was not considered severe.

Figs. 2, 3, and 4 show the drying rates of 1-inch hemlock under varying

[3] Small access ports in the main door would permit sample boards to be removed without opening the kiln door. If this procedure were being followed heavy asbestos gloves should be worn for safety.

Table 2.—RESULTS OF 19 CHARGES OF 1-INCH WESTERN HEMLOCK

Circ. F.P.M.	D.B. °F.	W.B. °F.	R.H. %	Wet Steam Sat.	Time in Hours				Moisture Content—%		Degrade*—%				Drying Rate per hr %
					Warm	Dry	Cool	Total	Initial	Final	N.	Sl.	M.	S.	
400	220	200	67	80	1	39½	2	42½	65.5	9.5	92	5	3	--	1.4
400	220	180	42	50	¾	28	1¾	30½	63.0	7.8	90	10	--	--	1.9
400	240	200	47	80	¾	17¾	2¼	20¾	58.4	9.4	78	8	7	7	2.7
400	240	180	30	50	¾	14¼	1½	16½	57.9	9.5	73	17	8	2	3.3
400	265	200	30	80	1¼	12¾	1½	15½	63.3	11.3	95	--	--	5	4.0
400	265	180	19	50	1¼	11¾	2	15	60.9	11.2	85	5	8	2	4.2
600	220	200	67	80	¾	30½	½	31¾	59.7	9.9	88	7	3	2	1.6
600	220	180	42	50	¾	19¾	1	21½	56.6	9.7	96	4	4	--	2.3
600	240	200	47	80	1	17	2½	20½	68.4	10.9	83	5	9	3	3.3
600	240	180	30	50	1	15	3	19	69.5	11.6	88	10	2	--	3.6
600	265	200	30	80	2	11¾	1¾	15½	67.9	11.5	97	--	3	--	4.8
600	265	180	19	50	2	12	2½	16½	69.5	11.8	87	3	5	5	4.8
900	220	200	67	80	¾	43	2½	46¼	77.7	10.4	91	5	4	--	1.5
900	220	180	42	50	¾	23¼	2	26	76.0	12.0	93	2	5	--	2.7
900	240	200	47	80	1¼	17½	1½	20¼	74.6	11.3	90	2	6	2	3.6
900	240	180	30	50	1¼	13¼	2¼	16¾	67.4	12.5	89	7	3	1	4.1
900	265	200	30	80	4¼	10½	2	16¾	57.1	9.0	93	4	3	--	4.5
900	265	180	19	50	4	10¼	3	17¼	53.5	8.7	77	11	10	2	5.3
1100	265	200	30	80	3¾	10¼	1¾	15¾	54.5	9.4	84	10	4	2	5.3

*N. None
Sl.—Slight
M.—Medium
S. Severe

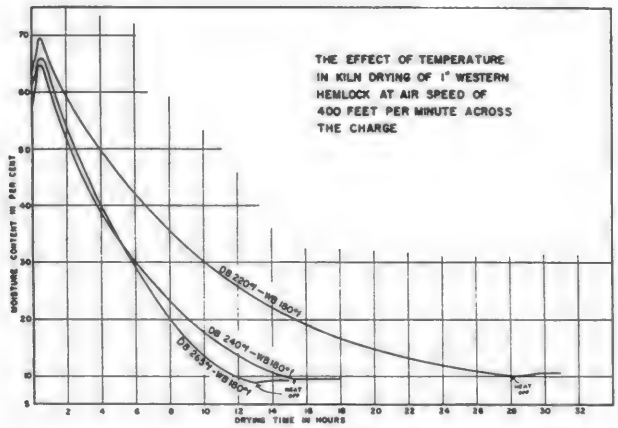

THE EFFECT OF TEMPERATURE IN KILN DRYING OF 1" WESTERN HEMLOCK AT AIR SPEED OF 400 FEET PER MINUTE ACROSS THE CHARGE
MOISTURE CONTENT IN PER CENT
DRYING TIME IN HOURS
DB 220°F – WB 180°F
DB 240°F – WB 180°F
DB 265°F – WB 180°F
HEAT OFF

Figure 2

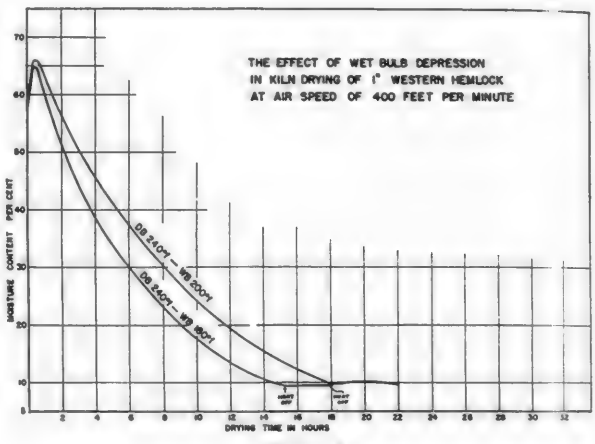

THE EFFECT OF WET BULB DEPRESSION IN KILN DRYING OF 1" WESTERN HEMLOCK AT AIR SPEED OF 400 FEET PER MINUTE
MOISTURE CONTENT PER CENT
DRYING TIME IN HOURS
DB 240°F – WB 200°F
DB 240°F – WB 180°F
HEAT OFF

Figure 3

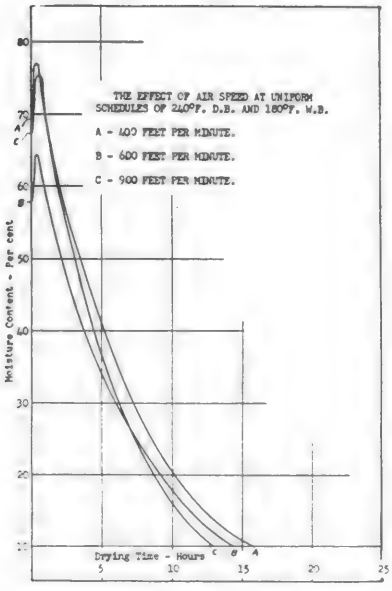

THE EFFECT OF AIR SPEED AT UNIFORM SCHEDULES OF 240°F. D.B. AND 180°F. W.B.
A - 400 FEET PER MINUTE.
B - 600 FEET PER MINUTE.
C - 900 FEET PER MINUTE.
Moisture Content - Per cent
Drying Time - Hours

Figure 4

conditions of temperature, steam saturation, and air speed. These drying rates were recorded after the scale was installed when it was possible to weigh the whole kiln charge at regular intervals.

General Observations

The data discussed in this paper are of a preliminary nature only, and much more work is required before definite and final recommendations can be made. Past research in respect to high-temperature drying, using superheated steam, disclosed that the construction materials in conventional kilns did not stand up to heat and resultant corrosion. That still holds true today. High-temperature kilns must be made of materials that do not deteriorate through the action of heat and superheated vapor. Aluminum seems to stand up satisfactorily and is one of the cheapest materials for this purpose. It is probable that materials such as brick, terra cotta, and others would also be suitable if given a protective coating.

There are many advantages in high-temperature drying. Speed of drying is probably the most important as far as a sawmill operator is concerned. On the other hand, since time in the kiln may be critical, the operator must be prepared any time of the day or night to discharge a unit and charge it immediately. If this is not done, much of the advantage of fast drying is lost.

Another advantage is the saving of space, which may be important to mills or woodworking plants with limited plant accommodation. These units will probably occupy only a third of the space required for a conventional kiln.

As yet, very little is known on the effect of high temperature on the wood

Table 3.—SCHEDULES, TIMES, MOISTURE CONTENT, AND DEGRADE OF SIX CHARGES OF 1-INCH DOUGLAS-FIR

Circ. F.P.M.	D.B. °F.	W.B. °F.	R.H. %	Wet steam sat.	Time in hours				Moisture content—%		Degrade—%			Severe
					Warm	Dry	Cool	Total	Initial	Final	None	Slight	Medium	
800	220	200	67	80	1	28	4	33	34	7	93	5		2
800	220	180	42	50	1	26	4½	31½	33	8	93		7	
800	240	200	47	80	1¾	18	4½	24¼	33	5	93	5	2	
800	240	180	29	50	2	14	5¼	21¼	32	5	92	7	1	
800	265	200	31	80	4	10	5	19	32	5	74	7	11	8
800	265	180	18	50	3	8	4¼	15¼	34	7	78	7	7	8

itself. It has a tendency to darken the wood slightly, especially the light species such as western hemlock and spruce. The few tests on strength values which have been made at the Vancouver laboratory have not been conclusive.

Some of the lumber was run through a molding machine at a commercial wood-working plant. The machining qualities appeared to be excellent. Test piles of air-dried, conventionally kiln-dried, and high-temperature dried lumber, erected outside show some indications that absorption of moisture is retarded in the high-temperature material.

Studies at the Ottawa laboratory have shown that, for eastern white spruce, final moisture content uniformity can be brought within acceptable limits by using a high circulation rate and periodic reversal of air flow. At the present time, studies are being made on yellow birch (an eastern hardwood) to determine the effect of temperatures, humidity, and air flow on the drying of this species.

At the Vancouver laboratory, work is being continued on the effect of temperature, humidity, and circulation on the drying of western Canadian species. Up to the present, tests have been made on 1-inch material. It is hoped shortly to commence studies on 2-inch hemlock and Douglas-fir. These thicknesses are normally more difficult to dry without degrade, and some modifications of high-temperature procedure may be necessary.

The Equilibrium Moisture Content—Relative Humidity Relationships of Selected Native and Foreign Woods[1]

NORMAN C. HIGGINS

Assistant Professor (Extension), Department of Forest Products, Michigan State University, East Lansing, Michigan

The equilibrium moisture content — relative humidity relationships was studied for a number of commercially important native and foreign woods. Additional data were obtained on volumetric shrinkages, fiber saturation points, hysteresis loops, specific gravities (on two bases) and the measurement of humidities over saturated salt solutions.

Summary

SIGNIFICANT DIFFERENCES in e.m.c. values among the 12 species studied were found throughout nearly the entire range of relative humidities, both in initial adsorption and in secondary desorption.

When comparing any two species, a lower fiber saturation point coincided with lower e.m.c. values, but this was found to be generally true only at the higher relative humidities.

Six of the twelve species studied, plus impregnated pine, had fiber saturation points below 20 per cent moisture content, with a low of 15.4 exhibited by East Indian rosewood.

Average volumetric shrinkage ranged from a low of 5.9 per cent for the more-heavily impregnated pine to a high of 20.2 for coigue. The relatively flat hysteresis loops of the impregnated pines, Andaman padouk, East Indian rosewood, teak, West Indian locust, Ceylon satinwood and western red cedar indicated good dimensional stability throughout a wide range of relative humidities, even though considerable differences in total volumetric shrinkages were noted.

Impregnation of southern yellow pine with 11.3 and 13.5 lbs. of phenolic resin per cu. ft. caused a considerable reduction in e.m.c. values, volumetric shrinkage, and fiber saturation point. These results, however, were essentially duplicated naturally by such woods as Andaman padouk, East Indian rosewood and teak.

The reduction of e.m.c. values of pine as a result of impregnation was found to be proportionately greater at the higher relative humidities than at the lower, and to be greater for desorption values than for adsorption. As a result of impregnation in the amounts stated, the hysteresis effect in pine was eliminated, or essentially so, at the lower relative humidities. A similar effect was noted in the case of coigue, which had no treatment.

In this experiment, the use of an electric hygrometer and sensing elements was not found to be satisfactory for the accurate measurement of relative humidities in small, enclosed atmospheres over saturated salt solutions.

It was found that a properly designed wet- and dry-bulb setup could be used for measuring higher relative humidities in a small, enclosed atmosphere over saturated salt solutions, and that a "salt" bulb and dry bulb could be used to determine when the atmosphere was in equilibrium with the solution.

A specific combination of desiccant and oven drying was found to give accurate dry weights for the size and species of samples used, many of which contained volatiles.

Procedure

Fifteen small samples (comprising 12 species), 1 x 1½ x ⅛ inch, with the ⅛ inch taken along the grain, were precisely cut from stock at room e.m.c., dried over calcium chloride, and then equalized (at 90° F.) at each of 4 humidities in initial adsorption. After the samples were slowly raised to fiber saturation point or above, they were equalized at each of the same 4 humidities in secondary desorption. This adsorption-desorption cycle was replicated 4 times with matched specimens. The commercial names, scientific names, and origin of the 15 samples are presented in Table 1.

[1] Condensation of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Forestry, School of Forestry, Pennsylvania State University. A previous condensation entitled "The Effect of Species on the Relative Humidity—Equilibrium Moisture Content Relationship" received second prize in the 1956 Wood Award competition.

The Author: Norman C. Higgins received a B. S. degree in general forestry from the University of New Hampshire, and M. F. degree in Wood Utilization from the School of Forestry, Pennsylvania State University. He presently serves as extension specialist in forest products at Michigan State University, Department of Forest Products. His experience includes many years of kiln drying native and foreign woods.

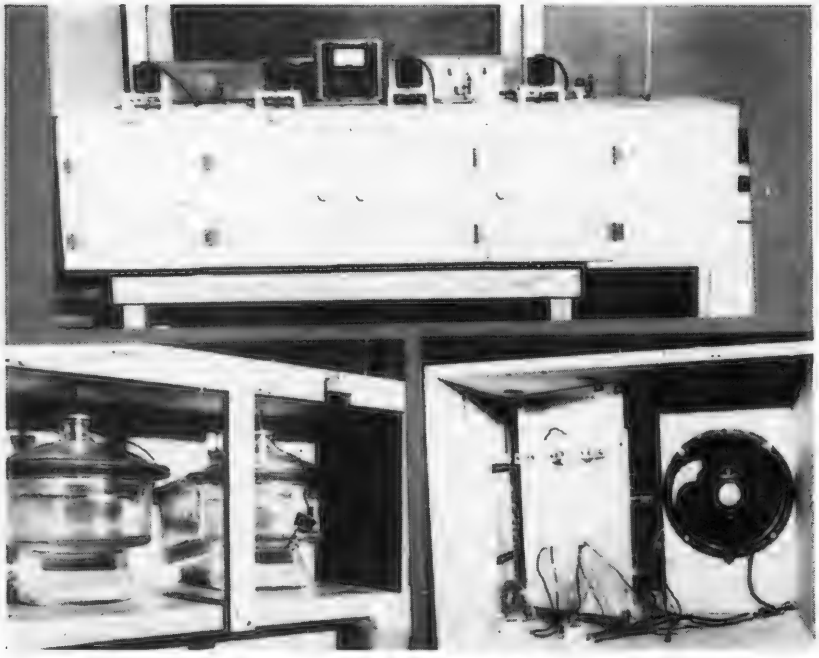


Fig. 1.—Constant temperature cabinet. Top—Overall view of cabinet, showing electric hygrometer, switch panel and motor mountings. Lower left—Desiccator jars with humidity sensing elements. Lower right—Carbon filament lamps and strip heaters used as heat source, and fan to provide circulation.

Four additional samples of determa were taken from a specimen in the original, green condition, and data were obtained for initial desorption as well as for initial adsorption and secondary desorption.

Only after all equilibrium weights had been obtained were dry weights, dry volumes, intermediate volumes (in desorption), and green volumes taken for all samples of the 4 replications, plus matched specimens of a fifth group.

Control of Temperature and Relative Humidity

The complete temperature-relative humidity setup is shown in Figure 1. The cabinet was equipped with the necessary heating units and control, air chamber, and fan to maintain a temperature of 90° F. Four different relative humidities were obtained by the use of saturated salt solutions. A large desiccator jar was used to hold each solution, and the level of the solutions extended well into the upper portion of the jar. Air circulation was provided within each jar, and periodic tests made with a potentiometer and thermocouples sealed within each jar usually showed 90° F. At no time was a variation greater than 0.2° F. noted.

The 4 salts used are listed in Table 2. A considerable excess of salt was always present, and the volume of the atmosphere was sufficiently small in relation to the potential of the salt solution so that a stable humidity was quickly reached and maintained, even when samples of high moisture content were desorbed.

Measurement of Humidity

Discrepancies were noted in the literature (3, 15) as to the exact relative humidity which the saturated solution of a specific salt would produce in the atmosphere above it at a given temperature. In order to read humidities directly, an electric hygrometer was used with sensing elements installed in each jar. Initial readings were the highest obtained. Thereafter, in general, the readings gradually declined over a period of several months. An investigation revealed that the relative humidities actually were not declining, and therefore it appeared evident that the sensing elements had been affected in some manner.

Two sets of small thermocouple wires were inserted through the sides of each jar and positioned in the atmosphere above the salt solution to function as a dry-bulb and wet-bulb unit (14). A wet-bulb wick was designed to cover the end of one of the leads, and extended into the salt solution. When the atmosphere was in equilibrium with the salt solutions, the dry bulb and "salt" bulb gave exactly the same readings. This simple setup served as an effective tool for determining quickly whether or not the atmosphere within the jar was in equilibrium with the salt solution. It was then realized that by use of such a setup it would be possible to determine whether relative humidities within the jars could be accurately determined by use of a "normal" dry- and wet-bulb setup with thermocouples. Exploring this further it was found that, by the use of a specially designed wick and water reservoir, humidity readings could be obtained consistently without affecting the equilibrium between atmosphere and salt solution. However, at least in this instance, accurate humidity readings could not be obtained at the two lowest humidities. This was probably due to the excessive difference in vapor pressures produced by the distilled water in the wick and the salt solution in the jar. No further experimenting along this line was done because of time limitations, but possible similar techniques for measuring practically any humidity were indicated.

Because of contradictions in the humidity data as a whole, it was still not positively known what the exact value was for each jar. For purposes of plotting curves of adsorption and desorption, all data were evaluated and an arbitrary value was assigned to each jar. These arbitrary values and all other data for each of the salts are presented in Table 2.

Equilibrium Weights and Dry Weights

All sample weights were made to the nearest 0.0001 gram by means of a chain-omatic balance and a weighing

Table 1.—COMMERCIAL NAMES, SCIENTIFIC NAMES, AND ORIGIN OF TEST MATERIAL

Sample* No.	Species: Commercial name	Species: Scientific name	Origin
1	Sitka spruce	Picea sitchensis	Western U.S.
2	Western red cedar	Thuja plicata	Western U.S.
3	Redwood	Sequoia sempervirens	Western U.S.
4	Southern yellow pine, S.y.p.1	Pinus sp.	Southern U.S.†
5	Southern yellow pine, S.y.p.1-i (11.3 lbs. phenolic resin/cu. ft.)	Pinus sp.	Southern U.S.
6	Southern yellow pine, S.y.p.2	Pinus sp.	Southern U.S.
7	Southern yellow pine, S.y.p.2-i (13.5 lbs. phenolic resin/cu. ft.)	Pinus sp.	Southern U.S.
8	Determa	Ocotea rubra	
9	Teak	Tectona grandis	Burma
10	Mexican mahogany	Swietenia macrophylla	Mexico
11	Coigue	Nothofagus dombeyi	Colombia
12	Andaman padouk	Pterocarpus dalbergioides	Andaman Islands
13	East Indian rosewood	Dalbergia latifolia	East Indies
14	West Indian locust	Hymenaea courbaril	West Indies
15	Ceylon satinwood	Chloroxylon swietenia	Ceylon

*Samples are listed in same order as sequence of weighings in first replication.
†Courtesy of Koppers Company, Inc.

Table 2.—SALTS USED, WITH CORRESPONDING PER CENT RELATIVE HUMIDITIES EXISTING ABOVE THE SATURATED SOLUTIONS AT 90° F.

Jar	Salt	Per cent relative humidity over saturated solution at 90° F.	Source of data
1	Potassium acetate, ($KC_2H_3O_2$) Merck reagent, fine crystals	19.3	(3)
		21.5	(15)
		21.9–19.8	Sensing element
		21.0	Arbitrary value
2	Potassium carbonate, (K_2CO_3) Merck reagent, anhydrous	41.5	(3)
		43.8	(15)
		42.2–41.3	Sensing element
		43.0	Arbitrary value
3	Potassium bromide, (K Br) Merck reagent, crystals	81.6	(3)
		80.2–77.7	Sensing element
		81.0	Normal wet bulb
		81.0	Arbitrary value
4	Ammonium phosphate, ($NH_4H_2PO_4$) Monobasic (primary), Merck reagent, crystals	92.9	(3)
		91.8	(15)
		95.9–93.8	Sensing element
		92.0	Normal wet bulb
		93.0	Arbitrary value

jar. It was originally planned to weigh the samples in each jar in randomly selected sequence, but preliminary experiments showed that this could produce decidedly erroneous results, especially at the two highest humidities in desorption. When desorbing these thin samples at high humidities, for example, if they were repeatedly exposed to drier air in the process of obtaining weights, they lost an appreciable percentage of moisture. This repeated loss and partial regain resulted in a gradual shifting downward toward the adsorption curve values. A specific weighing sequence was established for each of the four replications, however, and weights were obtained quickly for no more than one-third of a sequence during any 24-hour period.

This preliminary investigation also demonstrated that special care should be exercised in obtaining desorption equilibrium weights for a mixture of thick and thin samples. Under the same conditions, and during a brief period of time, it is only logical that a thin sample would lose a greater percentage of moisture than a thick sample. A repetitious occurrance of this in desorption would result in a greater shifting of the e.m.c. value of the thin sample toward the adsorption value. Thus it is possible that the e.m.c. value of the thin sample could erroneously be found to be considerably lower than that of the thick sample. The best way to avoid this would be to have an apparatus where all samples could be weighed without removal from the controlled atmosphere. Where such is not possible, however, accurate e.m.c. values for both thick and thin samples can be obtained if equilibrium between the atmosphere and the salt solution is quickly reached and maintained, and if equilibrium weights are first obtained for the thin samples.

Dry weights were not determined until after all equilibrum weights had been obtained. Preliminary experiments in obtaining accurate dry weights for such small samples, which contained varying amounts of extractives, resulted in the derivation of a fairly simple but reliable technique. (This technique could not be used if dry weights were obtained before starting the adsorption-desorption cycle.) The samples were dried over calcium chloride to approximately 1.0 to 2.0 per cent moisture content, then over phosphorus pentoxide to between 0.2 and 0.6 per cent, and then in the electric oven for one hour. No more than a single group of up to 4 samples was in the oven at any one time, and the samples were always in a specific location that had been calibrated for an average temperature of essentially 212° F. The vents were left almost closed, no samples were dried on high-humidity days, and samples were removed singly from the oven at 10-minute intervals. The weighing jar was weighed immediately before and after the obtainment of a sample weight. This procedure, plus the 10-minute interval, was found to be necessary because the jar itself lost weight during the weighing of each sample, and samples in the oven picked up weight during the opening and closing of the door. The preliminary experiments showed that unless such precautions were observed, dry weights could easily be in error by an amount equal to 1.0 per cent moisture content.

In any future experiments of this nature, it is recommended that all samples be taken to zero per cent moisture content over phosphorus pentoxide before the adsorption-desorption cycle is started. As will be discussed later, failure to do so in this experiment resulted in a certain amount of biased data that prevented more positive statements concerning unusual results obtained for coigue and the impregnated pines.

Specific Gravities and Volumetric Shrinkages

Specific gravities (on two bases) were determined for each sample of the 4 replications, and for each sample of an additional group. Dry volumes were taken by displacement in mercury. To obtain green volumes, the moisture content of the samples was slowly raised until finally they were soaked in distilled water for about one week, with an occasional vacuum being pulled. Five intermediate volumes (in desorption) were taken before green volumes were obtained.

Fiber Saturation Points

Average volumetric shrinkage and five intermediate shrinkages were plotted for each of the 15 samples so that hysteresis loops could be drawn for visual comparison among samples. A straight line and its point of interception with the moisture content axis were computed by a method of least squares. These interception points were considered to represent fiber saturation points.

Results and Conclusions

The e.m.c. values of all 4 replications are averaged together and presented in Table 3. The average moisture contents prior to initial adsorption are in the column labeled "calcium chloride".

An analysis of variance of the average e.m.c. values is summarized in Table 4. The significant differences in e.m.c. due to humidities and sorptions are to be expected on the basis of the work of previous investigators (4–13).

Table 3.—AVERAGE ADSORPTION AND DESORPTION EQUILIBRIUM MOISTURE CONTENTS OF 12 SPECIES OF FOREIGN AND DOMESTIC WOODS

Species	Ca Cl	Adsorption relative humidity, per cent				Desorption relative humidity, per cent			
		21	43	81	93	93	81	43	21
Sitka spruce	1.57	4.38	6.94	13.72	19.42	22.40	16.20	8.62	5.30
Western red cedar	1.99	4.30	6.08	9.36	12.62	15.13	12.17	7.68	5.10
Redwood	1.75	4.30	6.43	12.15	16.67	17.94	14.32	8.06	5.21
Southern pine 1	1.75	4.43	6.90	12.76	18.34	21.64	15.82	8.44	5.30
Southern pine 1-i	2.80	4.72	6.50	9.95	11.78	12.76	10.94	6.54	4.24
Southern pine 2	1.68	4.39	6.94	13.38	18.75	21.71	15.97	8.46	5.29
Southern pine 2-i	2.76	4.56	6.21	9.20	10.66	11.65	10.00	6.20	3.96
Determa	1.48	3.90	6.22	12.64	17.76	19.27	14.66	7.42	4.51
Teak	1.08	3.13	5.15	9.80	12.67	13.93	11.93	6.85	4.40
Mexican mahogany	1.71	4.46	7.11	12.98	17.08	19.58	16.08	9.17	5.73
Coigue	3.07	5.37	7.57	11.48	17.72	21.11	14.30	7.70	4.83
Andaman padouk	1.47	3.48	5.32	8.67	11.19	12.30	10.38	6.51	4.20
East Indian rosewood	1.69	3.62	5.56	9.41	11.55	12.12	10.62	6.74	4.39
West Indian locust	1.83	4.60	6.73	10.07	13.52	14.54	12.58	8.18	5.32
Ceylon satinwood	1.49	3.69	5.93	10.72	14.02	15.10	12.38	6.94	4.15

Table 4.—ANALYSIS OF VARIANCE OF EFFECT OF HUMIDITIES, SPECIES, AND SORPTIONS ON EQUILIBRIUM MOISTURE CONTENTS

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio*
Main Effects:				
Between humidities (H)	3	9,350.2	3,116.7	175.1
Between species (S)	14	1,156.9	82.6	4.6
Between sorptions (So)	1	246.8	246.8	17.0
First Order Interactions:				
H x S	42	745.9	17.8	29.7
H x So	3	43.5	14.5	24.2
S x So	14	40.2	2.9	4.8
Second Order Interaction:				
H x S x So	42	24.4	0.581	3.95
Subtotal	119	11,607.9		
Within Groups	360	52.9	0.147	
Total	479	11,660.8		

*All values were significant at the 0.1 per cent level.

A highly significant difference in e.m.c. values due to the effect of species indicates the species came to different values regardless of the humidity, or whether they were adsorbing or desorbing. The significant interactions show that, on the average, 1) differences in e.m.c. values between sorptions were not the same for all species; 2) differences in e.m.c. values between sorptions were not the same for all humidities; and 3) differences in e.m.c. values among species were not the same for all humidities.

Although the analysis of variance indicates significant e.m.c. differences among species, it does not indicate between which species or groups of species the differences occur. By use of a technique employing the Studentized range (1), the e.m.c. values were separated into homogeneous groups, as shown in Table 5, so that no value of any one group was significantly different at the 5 per cent level from any other value of the same group. The least number of groupings occurred at the lowest humidity in adsorption, and the greatest number at the next-to-highest humidity in adsorption.

Greater ranges in e.m.c. values occurred in desorption than in adsorption. The greatest range in values occurred in desorption at the highest humidity, as shown in Table 6.

Table 6.—VARIATION AND RANGE OF EQUILIBRIUM MOISTURE CONTENT VALUES FOR EACH HUMIDITY AND SORPTION

Jar	Sorption	Lowest e.m.c.	Highest e.m.c.	Range in e.m.c.
1	Desorption	3.96	5.73	1.77
	Adsorption	3.13	5.37	2.24
2	Desorption	6.20	9.17	2.97
	Adsorption	5.15	7.57	2.42
3	Desorption	10.00	16.20	6.20
	Adsorption	8.67	13.72	5.15
4	Desorption	11.65	22.40	10.75
	Adsorption	10.66	19.42	8.76

In general, Andaman padouk, East Indian rosewood, and teak had the lowest e.m.c. values of any of the untreated woods. Values of the more heavily impregnated pine were lower

Table 5.—AVERAGE EQUILIBRIUM MOISTURE CONTENTS SEPARATED INTO HOMOGENEOUS GROUPS

E.m.c.	Species	E.m.c.	Species
	Jar 1* Initial Adsorption		Jar 2†
5.37‡	Coigue	7.57	Coigue
4.72	Southern yellow pine 1-i	**7.11**	Mexican mahogany
4.60	West Indian locust	6.94	Southern yellow pine 2
4.56	Southern yellow pine 2-i	6.94	Sitka spruce
4.46	Mexican mahogany	6.90	Southern yellow pine 1
4.43	Southern yellow pine 1	6.73	West Indian locust
4.39	Southern yellow pine 2	6.50	Southern yellow pine 1-i
4.38	Sitka spruce	6.43	Redwood
4.30	Redwood	6.22	Determa
4.30	Western red cedar	**6.21**	Southern yellow pine 2-i
3.90	Determa	6.08	Western red cedar
3.69	Ceylon satinwood	**5.93**	Ceylon satinwood
3.62	East Indian rosewood	5.56	East Indian rosewood
3.48	Andaman padouk	5.32	Andaman padouk
3.13	Teak	5.15	Teak
	Jar 1 Secondary Desorption		Jar 2
5.73	Mexican mahogany	**9.17**	Mexican mahogany
5.32	West Indian locust	8.62	Sitka spruce
5.30	Southern yellow pine 1	8.46	Southern yellow pine 2
5.30	Sitka spruce	**8.44**	Southern yellow pine 1
5.29	Southern yellow pine 2	8.18	West Indian locust
5.21	Redwood	**8.06**	Redwood
5.10	Western red cedar	7.70	Coigue
4.83	Coigue	7.68	Western red cedar
4.51	Determa	**7.42**	Determa
4.40	Teak	6.94	Ceylon satinwood
4.39	East Indian rosewood	6.85	Teak
4.24	Southern yellow pine 1-i	6.74	East Indian rosewood
4.20	Andaman padouk	6.54	Southern yellow pine 1-i
4.15	Ceylong satinwood	**6.51**	Andaman padouk
3.96	Southern yellow pine 2-i	6.20	Southern yellow pine 2-i
	Jar 3§ Initial Adsorption		Jar 4**
13.72	Sitka spruce	**19.42**	Sitka spruce
13.38	Southern yellow pine 2	18.75	Southern yellow pine 2
12.98	Mexican mahogany	**18.34**	Southern yellow pine 1
12.76	Southern yellow pine 1	17.76	Determa
12.64	Determa	**17.72**	Coigue
12.15	Redwood	17.08	Mexican mahogany
11.48	Coigue	**16.67**	Redwood
10.72	Ceylon satinwood	14.02	Ceylon satinwood
10.07	West Indian locust	**13.52**	West Indian locust
9.95	Southern yellow pine 1-i	12.67	Teak
9.80	Teak	**12.62**	Western red cedar
9.41	East Indian rosewood	11.78	Southern yellow pine 1-i
9.36	Western red cedar	11.55	East Indian rosewood
9.20	Southern yellow pine 2-i	**11.19**	Andaman padouk
8.67	Andaman padouk	10.66	Southern yellow pine 2-i
	Jar 3 Secondary Desorption		Jar 4
16.20	Sitka spruce	22.40	Sitka spruce
16.08	Mexican mahogany	21.71	Southern yellow pine 2
15.97	Southern yellow pine 2	**21.64**	Southern yellow pine 1
15.82	Southern yellow pine 1	**21.11**	Coigue
14.66	Determa	19.58	Mexican mahogany
14.32	Redwood	**19.27**	Determa
14.30	Coigue	**17.94**	Redwood
12.58	West Indian locust	15.13	Western red cedar
12.38	Ceylong satinwood	15.10	Ceylon satinwood
12.17	Western red cedar	**14.54**	West Indian locust
11.93	Teak	**13.93**	Teak
10.94	Southern yellow pine 1-i	12.76	Southern yellow pine 1-i
10.62	East Indian rosewood	12.30	Andaman padouk
10.38	Andaman padouk	**12.12**	East Indian rosewood
10.00	Southern yellow pine 2-i	11.65	Southern yellow pine 2-i

*Jar 1, 21.0 per cent relative humidity.
†Jar 2, 43.0 per cent relative humidity.
‡Division between groups.
§Jar 3, 81 per cent relative humidity.
**Jar 4, 93 per cent relative humidity.

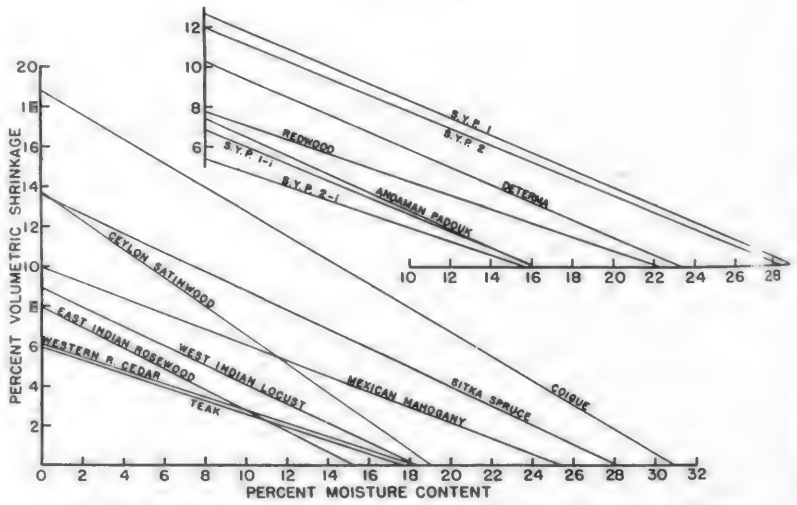


Fig. 2.—Shrinkage-moisture content curves for 12 native and foreign woods.

than these values at the highest humidity in adsorption and at all humidities in desorption.

Shrinkage-moisture content curves, based on average total volumetric shrinkage and 5 intermediate shrinkages and computed by a method of least squares, are shown in Figure 2.

When the shrinkage curves of teak and Ceylon satinwood are compared, it is apparent that the samples of Ceylon satinwood exhibited a proportionately greater reduction in fiber saturation point than in volumetric shrinkage, while the opposite is true in the case of teak. As will also be noted from Figure 2, the volumetric shrinkages and fiber saturation points of teak, western red cedar, East Indian rosewood, Andaman padouk, and the impregnated pines are quite similar.

Specific gravities, volumetric shrinkages, and fiber saturation points are shown in Table 7. Specific gravities (green volume basis) ranged from a low of 0.294 for western red cedar to a high of 0.942 for Ceylon satinwood. Total volumetric shrinkage (based on shrinkage-moisture content curves) ranged from a low of 5.43 per cent for the more heavily impregnated pine to a high of 18.80 per cent for coigue. Fiber saturation points ranged from a low of 15.36 per cent moisture content for East Indian rosewood to a high of 30.95 per cent for coigue.

Hysteresis Loops

The hysteresis loops for each of the 15 samples, plus the additional samples of determa, are presented in Figures 3, 4, 5 and 6. They should not be considered as being absolutely correct because of certain liberties taken in their construction, and because of a small amount of bias in some of the data. They are presented primarily to emphasize visually the differences in e.m.c. values, and differences in the general nature of the loops. The flattest loops, which indicate good dimensional stability over a wide range of relative humidities, are those of the impregnated pines, Andaman padouk, East Indian rosewood, teak, and western red cedar.

The most unusual loops are those for the impregnated pines and coigue. The slight crossing of the adsorption and desorption curves is explained by the fact that the e.m.c. values obtained in adsorption in jars 1 and 2 were erroneously high for these samples because of insufficient drying over calcium chloride before the start of adsorption. Since any shifting from a point on the desorption curve to the adsorption curve is effected gradually, the amount of bias in jar 1 is greater than in jar 2, and essentially eliminated in jar 3. Time limitations pre-

Table 7.—SPECIFIC GRAVITIES, VOLUMETRIC SHRINKAGES AND FIBER-SATURATION POINTS

Species	Specific gravity (av. of 5 replications)		Total volumetric shrinkage (average of 5 replications)	By method of least squares	
	Dry volume basis	Green volume basis		Total volumetric shrinkage	Fiber saturation point
Western red cedar	0.313	0.294	6.01	6.06	18.47
Redwood	.369	.343	7.86	7.80	22.25
Sitka spruce	.394	.340	13.75	13.56	28.15
Southern yellow pine 1	.444	.387	12.84	12.76	29.00
Southern yellow pine 2	.455	.400	12.14	12.02	28.39
Teak	.488	.459	6.10	5.89	17.88
Mexican mahogany	.492	.442	10.33	9.96	25.55
Southern yellow pine 1-i	.561	.520	6.92	6.90	16.13
Determa	.564	.503	10.78	10.36	23.33
Southern yellow pine 2-i	.625	.589	5.87	5.43	15.75
Coigue	.633	.505	20.16	18.80	30.95
Andaman padouk	.769	.710	7.62	7.47	16.08
East Indian rosewood	.854	.787	7.87	7.95	15.36
West Indian locust	.967	.880	8.97	8.83	18.41
Ceylon satinwood	1.093	.942	13.78	13.65	19.14

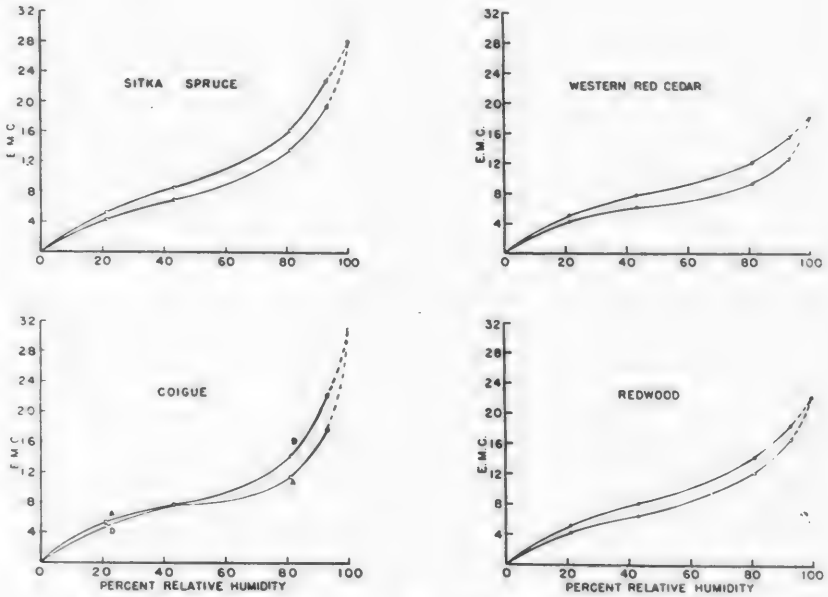


Fig. 3.—Curves of initial adsorption and secondary desorption for Sitka spruce, coigue, western red cedar and redwood.

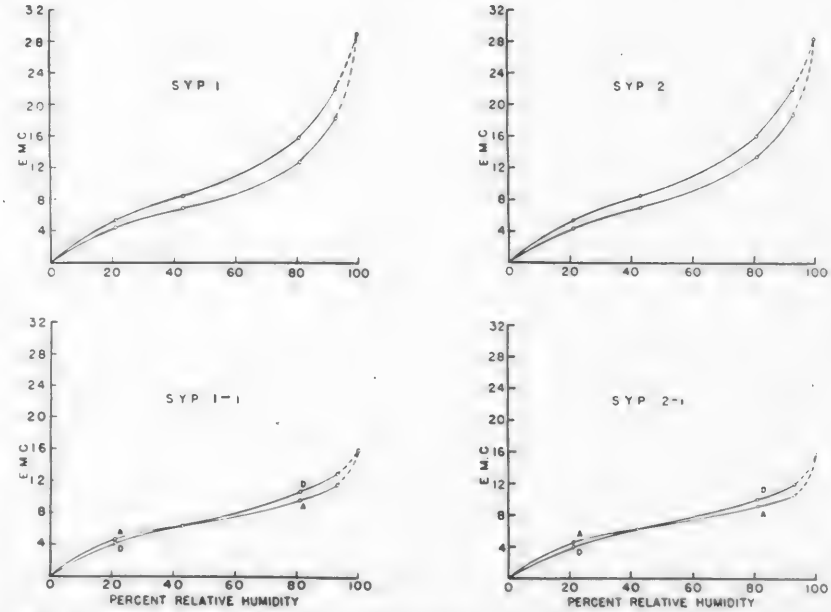


Fig. 4.—Curves of initial adsorption and secondary desorption for southern yellow pine 1, southern yellow pine 1-i, southern yellow pine 2, and southern yellow pine 2-i.

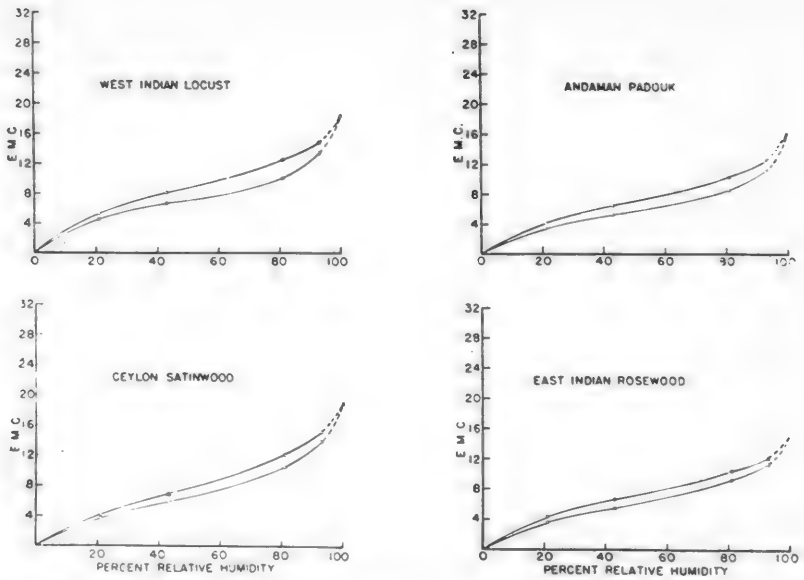


Fig. 5.—Curves of initial adsorption and secondary desorption for West Indian locust, Ceylon satinwood, Andaman padouk, and East Indian rosewood.

Table 8.—AVERAGE HYSTERESIS CONSTANTS BASED ON FOUR REPLICATIONS

Species	Relative humidity, per cent				Averages for all humidities
	21	43	81	93	
Sitka spruce	0.82	0.81	0.85	0.87	0.84
Western red cedar	.84	.79	.77	.84	.81
Redwood	.82	.80	.85	.93	.85
Southern yellow pine 1	.84	.82	.80	.85	.83
Southern yellow pine 2	.83	.82	.84	.86	.84
Southern yellow pine 1-i	1.11	1.00	.91	.92	.98
Southern yellow pine 2-i	1.15	1.00	.92	.92	1.00
Determa	.86	.84	.86	.92	.87
Teak	.71	.76	.82	.91	.80
Mexican mahogany	.78	.78	.81	.88	.81
Coigue	1.11	.98	.80	.84	.93
Andaman padouk	.83	.82	.84	.91	.85
East Indian rosewood	.82	.82	.88	.96	.87
West Indian locust	.86	.82	.80	.93	.85
Ceylon satinwood	.89	.86	.86	.93	.88
Averages for all species	.88	.85	.84	.90	.87
Averages for all species excluding coigue and the impregnated pines	.82	.81	.83	.90	.84

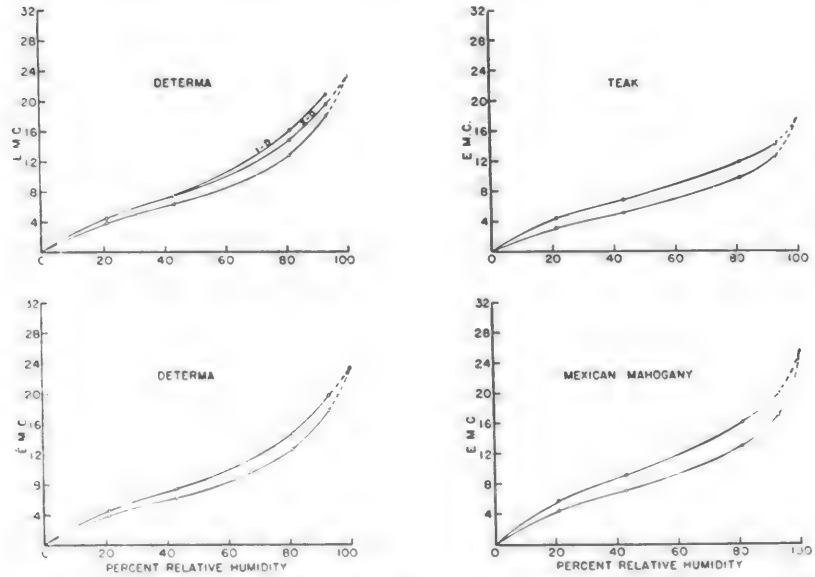


Fig. 6.—Curves of initial desorption, initial adsorption, and secondary desorption for determa, and curves of initial adsorption and secondary desorption for determa, teak and Mexican mahogany.

vented the taking of additional data to establish true e.m.c. values for coigue and impregnated pine at the two lowest humidities.

On the basis of a study of existing information, experimental data, and techniques used, the only conclusion that may be drawn is that the curves of the impregnated pines do not cross but are joined, or nearly joined, from zero per cent relative humidity to somewhere in the neighborhood of 40 per cent relative humidity. The same conclusion can be drawn for coigue, with the exception that the curves begin to diverge more rapidly, and that any point of actual joining is probably lower down on the humidity scale. According to Urquhart and Williams (12), the desorption and adsorption curves of cellulose become joined just prior to zero per cent relative humidity. Since coigue and the impregnated pines were dried simultaneously over calcium chloride with the other samples, and since their e.m.c. values were excessively high over calcium chloride, it is entirely possible that their adsorption and desorption curves become joined at an appreciable distance from the origin.

All 3 sorption curves, which represent average e.m.c. values for the 4 additional samples of determa, are shown in Figure 6. The secondary desorption curve joins the initial desorption curve at a little less than 40 per cent relative humidity, which is in good agreement with the statement by Seborg (4) to the effect that such curves join at approximately 30 per cent relative humidity. The constancy of the relative humidities in the jars is further attested by the close agreement of the average e.m.c. values of these samples with those of the 4 replications, and by the fact that an interval of 6 months occurred in taking portions of the two sets of data.

Average hysteresis constants for each of the samples are shown in Table 8. If the values for the impregnated pines and coigue, which are biased at the two lower humidities, are excluded, the average hysteresis constant (for all species and all humidities) becomes 0.84, which agrees with published data. A slight bias in the case of several of the heaviest samples may also have occurred at the highest humidity because of the possibility that insufficient pickup of moisture might have occurred before start of desorption. With this in mind and with reference to Table 8, it can be stated that the average hysteresis constant for all untreated samples (excluding coigue) ranged from approximately 0.80 at the lowest humidity to approximately 0.88 at the highest humidity.

The data in Table 9 show that teak, Mexican mahogany, and western red cedar have abnormally low average hysteresis constants and that East Indian rosewood, determa, Ceylon satinwood and coigue have abnormally high average hysteresis constants. Coigue is unusual in that its hysteresis constant is abnormally high at the two lowest humidities, decreases to an abnormally low value at the next higher humidity, and then becomes high again.

Table 9.—AVERAGE HYSTERESIS CONSTANTS GROUPED BY MEANS OF THE PRINCIPLE OF THE STUDENTIZED RANGE

Average hysteresis constant	Species
1.00	Southern yellow pine 2-i
.98	Southern yellow pine 1-i
.93	Coigue
.88	Ceylon satinwood
.87	Determa
.87	East Indian rosewood
.85	Redwood
.85	Andaman padouk
.85	West Indian locust
.84	Sitka spruce
.84	Southern yellow pine 2
.83	Southern yellow pine 1
.81	Western red cedar
.81	Mexican mahogany
.80	Teak

No attempt has been made in this study to offer any complete explanations for the variations encountered in the e.m.c. values, or to explore all the interrelationships of the various data presented. A few observations are considered to be pertinent, however.

General Observations

The impregnation of pine apparently results in a greater blocking of capillaries than of hydroxyl ions. However, even with an impregnation of 13.5 lbs. of phenolic resin per cu. ft., hysteresis is still evident at the higher humidities. Coigue contains but little extractives and is susceptible to collapse, which may account for its high volumetric shrinkage, high fiber saturation point, and great divergence of sorption curves at the higher humidities.

Some of the low e.m.c. values and narrow hysteresis loops may be accounted for by the presence of a large amount of extractives. Nearn (2) showed that e.m.c. values were appreciably increased by removal of water-soluble extractives.

Tropical woods, in general, have a fairly high ratio of lignin to cellulose, which is considered as implying a reduced number of hydroxyl ions. On the other hand, lignin has a lower average hysteresis constant than cellulose, and a high amount of lignin might tend to result in a wider hysteresis loop.

The fiber saturation point of wood is generally considered to be somewhere between 25 and 30 per cent moisture content. As demonstrated in this study, there are undoubtedly many species of wood whose fiber saturation points are between 15 and 20 per cent moisture content. On the basis of this study, it is conceivable that there are some whose fiber saturation points are less than 15 per cent moisture content.

The data for the untreated and treated pines bear further witness to the fact that, if complete dimensional stability of wood in service is to be obtained, the fiber saturation point must be reduced to approximately the lowest e.m.c. value the wood would normally attain in service. Another way of expressing this would be to say that there would be no change in e.m.c. values under service conditions.

This study further demonstrated that it is possible to measure relative humidities in the upper range in small, enclosed atmospheres over saturated salt solutions by means of a normal wet bulb and dry bulb—providing the wet- and dry-bulb setup is properly designed, and adequate circulation is provided. It was further shown that a "salt" bulb and dry bulb provide a simple means of determining when the enclosed atmosphere is in equilibrium with the salt solution. The possibility was also indicated that lower humidities could be calculated by formula (14) through use of a dry-bulb and wet-bulb setup in which a salt other than that used for the controlling solution would be used for the wet-bulb wick. However, this would probably be possible only if the order of magnitude of the vapor pressures of the two salts was such that an optimum differential existed. The use of an organic liquid (miscible with water), rather than a second salt, was also considered to be a distinct possibility.

Literature Cited

1. Bennett, C. A. and N. L. Franklin. 1954. *Statistical analysis in chemistry and the chemical industry.* 724 p. New York: John Wiley and Sons, Inc.
2. Nearn, W. T. 1955. "Effect of water soluble extractives on the volumetric shrinkage and equilibrium moisture content of eleven tropical and domestic woods." *Pennsylvania State University Agric. Exper. Sta. Bull.* No. 598:1–38.
3. O'Brien, F. E. M. 1948. "The control of humidity by saturated salt solutions." *J. Scientif. Instr. and of Phys. in Ind.* 25, No. 3:73–76.
4. Seborg, C. O. 1937. "Hysteresis in water sorption by paper-making materials." *Ind. and Eng. Chem.* 29:169–172.
5. Sheppard, S. E. 1933. "The structure of xerogels of cellulose and derivatives." *Trans. Faraday Soc.* 29:77–85.
6. ————, and P. T. Newsome. 1934. "The sorption of water by cellulose." *Ind and Eng. Chem.* 26, No. 3: 285–290.
7. Stamm, A. J. 1952. "Surface properties of cellulosic materials." *Wood chemistry.* Edited by Louis E. Wise and Edwin C. Jahn. Vol. 2 2nd ed., 1343 p. New York: Reinhold Publishing Corporation.
8. ————, and W. K. Loughborough. 1935. "Thermodynamics of the swelling of wood." *J. Phys. Chem.* 39:121–132.
9. ————, and S. A. Woodruff. 1941. "A convenient six-tube vapor sorption apparatus." *Ind. and Eng. Chem., Anal. Ed.* 13:836–838.
10. Urquhart, A. R., and N. Eckersall. 1930. "The moisture relations of cotton. vii—A study of hysteresis." *J. Textile Inst.* 21:T499–T510.
11. ————, and A. M. Williams. 1924. "The moisture relations of cotton. The taking up of water by raw and soda-boiled cotton at 20° C." *J. Textile Inst.* 15:T138–T147.
12. ————. 1924. "The moisture relations of cotton. The adsorption and desorption of water by soda-boiled cotton at 25° C." *J. Textile Inst.* 15: T433–T442.
13. ————. 1924. "The moisture relations of cotton. The effect of temperature on the adsorption of water by soda-boiled cotton." *J. Textile Inst.* 15:T599–T572.
14. Williams, G. C., and R. O. Schmitt. 1946. "Humidity measurements in presence of water-soluble salts." *Ind. and Eng. Chem.* 38, No. 9:967–974.
15. Wink, W. A., and G. R. Sears. 1950. "Instrumentation studies LVII. Equilibrium relative humidities above saturated salt solutions at various temperatures." *Tappi.* 33, No. 9:96A–99A.

The Appearance and Decay Resistance of Discolored Aspen[1]

RALPH L. HOSSFELD

Associate Professor, School of Forestry, University of Minnesota

JAMES C. OBERG

Wood Technologist, Technical Center, Weyerhaeuser Timber Co., Longview, Wash.

DAVID W. FRENCH

Associate Professor, Division of Plant Pathology and Botany, University of Minnesota

Discolored material associated with knots, Nectria canker, and wetwood was shown to be more resistant to decay than were sapwood controls. Alcohol extracts from fluorescent wood were more toxic toward test organisms than were extracts from non-fluorescent wood.

Introduction

ONE OF THE WIDELY OCCURRING DEFECTS in aspen is discolored wood. Atwell[2] has reported that certain heart-rots are associated with the most serious discolorations of pulpwood. Extensive discoloration has also been observed in association with Nectria canker (Figs. 1 and 2), Hypoxylon canker, "wetwood", knots (Fig. 3), and mechanical injury. Although it has been noted that the discolored wood surrounding knots is relatively durable against decay, it is generally agreed that both normal heartwood and sapwood of aspen are relatively non-durable.

During the evaluation of a field-service test of preservative-treated fence posts, it was noted in the aspen series that zones of perfectly sound wood still remained in the untreated controls after six years of soil exposure. Wood adjacent to these zones was completely decayed. Fig. 4 illustrates the appearance of a zone of durable material in relation to the completely decayed portion of a post. Sections B-1 and B-2 illustrate the presence of durable wood in association with a knot, while sections A-1 and A-2 illustrate a zone of durable wood that could not be directly related to the presence of knots.

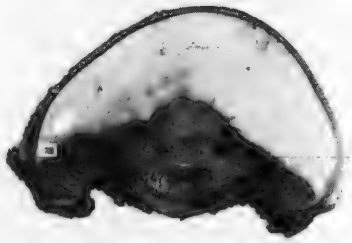


Fig. 1.—Discoloration associated with Nectria canker. The arrow indicates the location of the sections shown in Figs. 6 and 7.

In a parallel study of the chemistry of the extractives of discolored aspen wood,[3] it has been found that discolorations such as that associated with Nectria canker are often circumscribed by an irregular zone of intensely fluorescent material when examined under ultraviolet light. Fig. 5 is a photograph of a discolored section taken under ultraviolet light. The lighter

[1] Submitted as Paper No. 3818 in the Scientific Journal Series of the University of Minnesota Agricultural Experimental Station.

[2] Atwell, E. A. 1956. Decay and discolorations in poplar pulpwood. Technical Note No. 1, Forest Products Laboratory of Canada, Ottawa.

The Authors: Ralph Hossfeld holds a B.S. degree in chemical engineering from the University of Idaho. He also has a M.S. from Idaho and a Ph.D. from the University of Minnesota.

James Oberg holds B.S. and M.S. degrees in Wood Technology from the University of Minnesota. After graduation, he was employed as a research technologist at the U. S. Forest Service Central States Experiment Station research center at Carbondale, Ill., before he joined Weyerhaeuser.

[3] Oberg, J. C., R. L. Hossfeld, and F. H. Kaufert. 1956 Fluorescent materials associated with discoloration in aspen. TAPPI 39: No. 7. 470.

Fig. 2.—The external appearance of a Nectria canker in aspen, which is also shown in longitudinal section. The cause of the central column of discoloration is indeterminant.

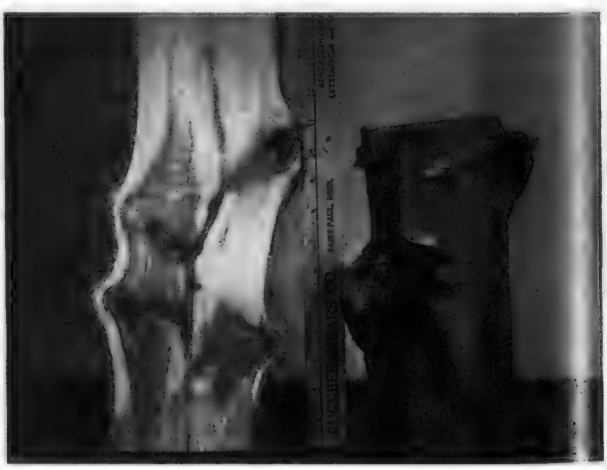


Fig. 3.—Typical appearance of discoloration associated with knots in an otherwise sound specimen of aspen.

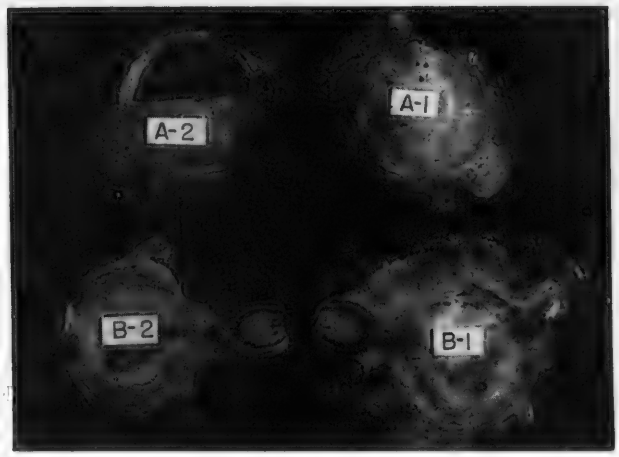


Fig. 4.—Sections taken from an untreated aspen post showing the presence of durable wood after 6 years of exposure in a test plot. Section A-1 represents the condition of the post as removed from the ground. Section A-2 is the matching face of the adjacent section showing a zone of sound wood remaining after partial excision of the completely decayed wood. Section B-1 represents a section through a knot, and Section B-2 is the matching face from which all decayed wood has been excised. The zones of sound wood in sections B-1 and B-2 demonstrated a yellow fluorescense when observed under ultraviolet light.

colored annular zone represents a region of intense yellow fluorescense.

Figs. 6 and 7 are photomicrographs that illustrate the development of tyloses in the vessels and the accumulation of globules of extraneous material in the ray cells in the region of demarcation between fluorescent discolored wood and normal sapwood. Gelatinized fibers are also shown to be profusely evident, although it cannot be said that their presence is associated with the development of the Nectria canker.

The similarity between the configuration of this zone of fluorescense and the zone of durable wood in section A-2 of Fig. 4 is apparent, and in part led to the development of the present study. The objective of this study was to evaluate the gross behavior of discolored aspen wood toward selected wood decaying fungi, and to determine the relative decay resistance of excised fluorescent and non-fluorescent discolored wood toward these fungi in soil-block tests. The study included a determination of the agar-plate toxicity of the alcohol extracts of the respective materials toward the organisms.

Soil-Block Decay Tests

Soil-block decay tests were carried out in 8-ounce French jars, as illustrated in Fig. 8, approximately half-filled with rich loam soil adjusted to 40 per cent moisture content. Feeder strips of aspen sapwood were placed on the soil, and the units were sterilized in the autoclave and inoculated with the test organism.

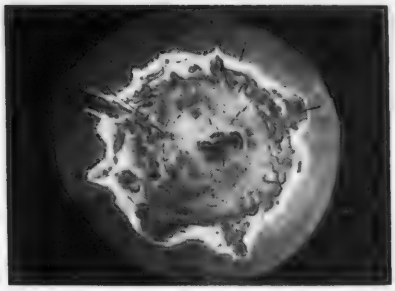


Fig. 5.—Photograph of a section of discolored aspen taken under ultraviolet light. The lighter zone surrounding the central area of discoloration represents a region of intensely brilliant yellow fluorescense.

Gross Evaluation: Material for this phase of the study was collected at the University of Minnesota Forest Research Center, Cloquet, Minnesota, and consisted of samples of discolored wood from 50 aspen trees (*Populus tremuloides* Michx.). The samples were classified according to their association with the presence of Nectria canker, knots, *Saperda sp.*, mechanical injury, and "wetwood".

Groups of ten replicate specimens were selected randomly from each of these classes. The test specimens as placed in the culture jars were ½ by ½ by 1½ inch blocks that had been previously dried to constant weight at 105° C. and surface sterilized by steaming over a container of boiling water. The cultures were stored under normal room conditions for a period of 90 days after which the blocks were removed, the mycelial mat removed, and again dried to constant weight. The test organisms were *Polyporus tulipiferus, P. versicolor,* and *P. adustus.*

The results are given in Table 1. Since it was recognised that a great deal of variation can be expected in a test of this nature, an analysis of variance was applied to the data to pinpoint the sources of the total variation.

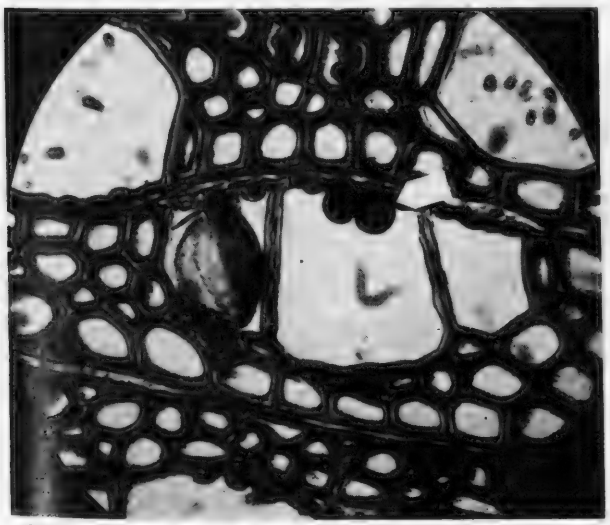


Fig. 6.—A photomicrograph showing the development of tyloses in the frontal zone of discoloration designated in Fig. 1.

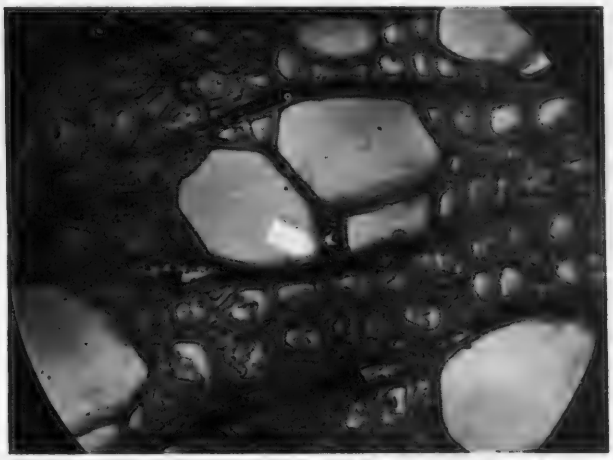


Fig. 7.—Photomicrograph showing the occlusion of ray tissue by accumulated extraneous material. This section was taken in the same region as that of Fig. 6.

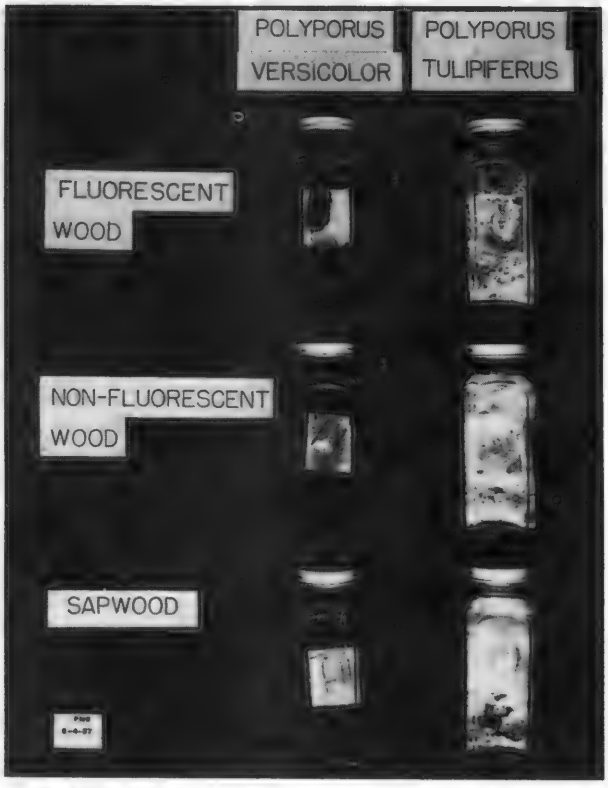


Fig. 8.—The appearance of selected cultures from a soil-block decay test comparing fluorescent and non-fluorescent discolored aspen wood.

The results of this analysis are given in Table 2.

A number of conclusions may be drawn from this portion of the study. These conclusions are made with the reservation that they are based on a limited sample of aspen wood and therefore may not necessarily describe the decay resistance of all discolored aspen wood. It is felt that these results are substantial enough, however, to infer that the behavior of a more representative sample might be similar.

The three organisms have shown varying degrees of ability to attack the sample of aspen used. A comparison of the overall mean percentage weight losses of the test specimens grouped by organisms shows the greatest loss in the case of *Polyporus tulipiferus* (42.0 per cent), followed by *P. versicolor* (32.6 per cent), and *P. adustus* (27.2 per cent).

Three of the classes of discolored wood show definite resistance to decay, irrespective of the organism. A comparison of the overall mean percentage weight losses grouped by discoloration class shows knots, Nectria, and wetwood to be decay resistant. Discolored wood associated with mechanical wounds and *Saperda sp.* showed weight losses not significantly different from those of the sapwood control.

Fluorescent Versus Non-fluorescent Discolored Wood: The material used in this part of the study was obtained as partially dried aspen lumber from a local lumber yard, and was selected only for the presence of discoloration. Justification for this type of sampling is based on a previous report[4], in which it was shown chromatographically that the pattern of fluorescent constituents in the alcohol extractives of discolored wood was uniform and independent of the class of material with the exception of that associated with knots. The fluorescent material associated with knots was excluded from the present sample since it was shown to contain extractive components not present in the other classes.

Preparation of the specimens for this test involved a necessary departure from the accepted soil-block technique. Blocks of discolored wood were cut from the lumber, and the zones of fluorescense were excised under ultraviolet light. A sampling of pure fluorescent and non-fluorescent discolored wood was thus obtained in the form of splints approximately 1/8 by 3/4 inch in size. These splints were then assembled into uniform bundles 1/2 by 3/4 inch and tightly bound together with a short length of stainless steel wire. Control specimens consisted of comparable bundles of splints taken from adjacent normal sapwood. Before the bundles were placed on the feeder strips, they were conditioned in an oven for 24 hours at 70° C., weighed, and sterilized in the autoclave for 10 minutes at 5 psi pressure. This relatively mild treatment in the autoclave was used in lieu of surface steriliza-

Table 2.—AN ANALYSIS OF VARIANCE BASED ON THE DATA OF TABLE 1

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F" Test Actual	5%	1%
Between species	2	47.934	23.967	20.3	3.06	4.75
Between discolor.	5	241.107	48.221	40.9	2.27	3.14
Interaction	10	66.458	6.649	5.6	1.89	2.44

Table 1.—LOSS IN WEIGHT OF VARIOUS CLASSES OF DISCOLORED ASPEN WOOD WHEN SUBJECTED TO SOIL-BLOCK DECAY TEST. ALL VALUES ARE PER CENT LOSS BASED ON THE OVEN DRY WEIGHT OF THE ORIGINAL SPECIMENS

Organism	Control		Wound	Saperda	Knots	Wetwood	Nectria	Overall Average
P. versicolor	36.5	34.6	41.7	44.6	16.5	40.2	31.6	
	35.7	47.3	43.8	24.8	18.7	12.9	43.5	
	49.1	34.0	55.6	13.3	36.8	19.2	33.4	
	47.0	60.1	50.9	22.3	28.4	17.1	29.1	
	47.6	33.8	35.1	11.6	14.5	29.9	36.7	
	49.3	35.9	45.0	20.4	30.2	19.5	7.6	32.6
	39.4	49.0	43.2	17.6	33.3	28.8	4.1	
	48.2	45.2	47.1	25.1	17.2	31.7	25.2	
	47.9	32.5	47.2	46.2	1.4	24.3	20.6	
	35.4	51.2	48.4	47.8	17.6	16.2	3.7	
Average	43.0		45.8	27.4	21.5	24.0	23.6	
P. tulipiferus	45.8	53.7	46.9	67.5	8.3	25.0	13.7	
	51.7	47.4	57.7	67.6	29.4	27.0	50.7	
	50.2	64.5	30.3	56.9	2.2	7.6	26.8	
	47.5	60.3	45.2	61.6	4.8	4.7	20.8	
	52.0	51.9	37.6	68.5	10.0	26.4	25.9	
	73.0	65.5	40.5	64.1	40.3	40.1	00.6	42.0
	58.8	57.8	53.2	67.0	49.6	26.5	39.1	
	47.9	68.4	58.5	57.1	5.9	52.3	10.5	
	51.8	67.1	58.1	60.8	3.6	49.8	28.9	
	42.7	59.5	32.2	66.2	31.8	56.6	5.6	
Average	55.9		46.0	63.7	18.6	31.6	22.2	
P. adustus	20.6	25.2	29.1	52.0	32.9	18.7	0.9	
	27.3	28.6	35.5	28.4	4.5	15.2	7.4	
	29.7	26.6	36.2	33.3	0.9	27.5	9.4	
	13.8	28.6	25.0	31.1	22.3	23.5	11.6	
	11.7	29.4	27.7	51.6	4.7	36.1	9.8	27.7
	31.1	43.7	30.2	60.6	7.4	15.8	26.4	
	38.6	38.9	33.3	54.4	7.9	18.0	0.0	
	38.6	31.9	33.6	52.3	32.3	40.7	5.2	
	42.6	24.4	36.1	32.2	23.3	27.1	23.0	
	37.0	32.4	40.0	45.5	8.8	31.8	15.1	
Average	33.0		32.7	44.1	14.5	25.4	11.2	
Overall Average	43.7		42.6	40.6	19.0	26.3	20.2	

tion by steaming or dipping in boiling water in order to reach the surfaces of splints in the interior of the bundles.

At the conclusion of the 90-day test period, the bundles were removed from the jars, the mycelial mat was carefully removed when possible, and the bundles were again conditioned as above before they were weighed. Thirty sample bundles, ten from each class, were divided equally between *Polyporus tulipiferus* and *P. versicolor* so that bundles of each class taken from the same board were tested against the same organism. The results of this test are given in Table 3. The ability of the organisms to attack the samples was in the same order as in the previous test. Although the differences in overall mean weight loss between the classes of wood were not statistically significant, they are biologically important, particularly when considered along with the toxicity test described below. The trend of these data suggests that the zones of fluorescent discolored wood may be more resistant to decay than the non-fluorescent discolored wood.

Two factors may have contributed to the extreme variability of weight losses in this and the previous test. In the initial test, the toxic extractive content of individual test specimens could not be determined without destruction of the sample, and thus constitutes an important unknown variable. In the second test, variability of extractive content in the samples is an equally serious consideration in addition to an indeterminate variability introduced by the unorthodox method of construction of the test samples.

Toxicity Tests of Extracts

Three hundred grams of non-fluorescent discolored wood and 128 grams of fluorescent discolored wood were excised from the same sample and in the same manner as described for the soil-block decay test. The material was reduced in a hammer mill, and was exhaustively extracted with ethyl alcohol in a Soxhlet apparatus. The solvent was removed from the extracts by distillation under vacuum. The yield of extractive in each case amounted to 4.5 per cent of the air-dry weight of the original sample. The extractive was redissolved in a measured volume of acetone and added proportionately to flasks of hot, freshly prepared and sterilized Difco-Bacto malt agar to give two series of media containing 0.25, 0.50, 1.0, 3.0, and 5.0 per cent by weight of the respective extracts. Control media were prepared by the addition of the corresponding volumes of acetone alone. After volatilization of the solvent, the warm media were poured into petri dishes, cooled, and inoculated with uniform circles of mycelium-bearing agar taken from fresh cultures of *P. tulipiferus* and *P. versicolor* as required. The cultures were kept under protective cover at room temperature for a period of 14 days, with periodic measurement of the progress of growth.

The results of this test are recorded in Tables 4 and 5 and illustrated in Fig. 9. The extract from the zone of fluorescent wood was shown to have a toxicity toward both organisms at 1.0 per cent concentration. The extract from the zone of non-fluorescent discolored wood was shown to have a toxicity toward both organisms at 3 per cent concentration. Although toxicity tests such as these may not be directly related to the degree of durability of the wood from which the extractive was obtained, the results of the toxicity test are in support of the inferred trend of the corresponding soil-block tests.

As a corollary to the toxicity test, chromatograms were prepared from the two extracts by the technique described in an earlier report.[3] It was observed that, although the original discolored wood from which the extract

Table 3.—LOSS IN WEIGHT OF FLUORESCENT AND NON-FLUORESCENT DISCOLORED WOOD WHEN PLACED IN SOIL-BLOCK DECAY TEST. ALL VALUES ARE IN PER CENT, BASED ON THE OVEN DRY WEIGHT OF THE ORIGINAL SPECIMEN

Organism	Control	Fluorescent	Non-Fluorescent	Overall Average
Polyporus versicolor	41.7	42.4	34.1	
	43.4	8.4	31.4	
	46.7	67.9	46.7	36.9
	12.8	38.9	31.4	
	50.3	16.9	40.9	
Average	39.0	34.9	36.9	
Polyporus tulipiferus	21.0	31.7	76.6	
	74.0	55.9	44.8	
	72.9	40.0	72.8	54.9
	72.5	51.7	33.1	
	71.7	51.3	54.8	
Average	62.4	46.1	56.4	
Overall Average	50.7	40.5	46.6	

Table 4.—RESULTS OF TOXICITY TEST OF THE FLUORESCENT AND NON-FLUORESCENT EXTRACTS OF DISCOLORED ASPEN AND ACETONE CONTROLS* AGAINST *POLYPORUS TULIPIFERUS*. FIGURES REPRESENT DIAMETER GROWTH IN MILLIMETERS

Extract per cent, by weight	Plate	Number of days after inoculation: Fluorescent 2	4	6	9	11	13	Non-fluorescent 2	4	6	9	11	13
5.0	a	No plates at this concentration											
	b												
3.0	a	--						†	†	†	†	16	22
	b							†	†	†	20	26	30
1.0	a	16	19	25	35	45	55	20	25	35	50	65	85
	b	17	18	22	35	40	50	19	25	35	50	65	80
0.5	a	22	25	35	50	65	80	20	30	40	65	80	90
	b	20	24	35	50	70	80	22	30	40	65	85	90
0.25	a	20	30	45	70	85	90	23	40	55	85	90	‡
	b	22	35	50	70	80	90	20	35	55	80	90	‡
0.0		40	65	90	‡			40	70	90	‡		

*The growth in all acetone controls, which ranged from 16.7% to 0.25% (solvent per cent by volume), reached full plate or 90 mm after 9 days.
†Indicates growth on the circle of inoculum only.
‡Ninety mm is full plate diameter.

Table 5.—RESULTS OF TOXICITY TEST OF THE FLUORESCENT AND NON-FLUORESCENT EXTRACTS OF DISCOLORED ASPEN AND ACETONE CONTROLS* AGAINST *POLYPORUS VERSICOLOR*. FIGURES REPRESENT DIAMETER GROWTH IN MILLIMETERS

Extract per cent, by weight	Plate	Number of days after inoculation: Fluorescent 2	4	6	9	11	13	Non-fluorescent 2	4	6	9	11	13
5.0	a	No plates at this concentration											
	b												
3.0	a							†	†	18	30	40	45
	b	--	--	--	-								
1.0	a	13	13	20	30	40	50	15	23	35	55	65	70
	b	15	15	22	35	45	55	15	24	35	55	70	75
0.5	a	17	27	40	70	70	80	18	35	50	70	80	80
	b	17	26	40	70	70	90	17	30	45	65	75	80
0.25	a	20	35	50	70	75	80	16	35	50	75	80	80
	b	19	30	50	70	80	90	25	40	55	70	80	80
0.0		30	55	80	90	‡		30	60	90	‡		

*The growth in all acetone controls, which ranged from 16.7% to 0.25% (solvent per cent by volume), reached full plate or 90 mm after 9 days.
†Indicates growth on the circle of inoculum only.
‡Ninety mm is full plate diameter.

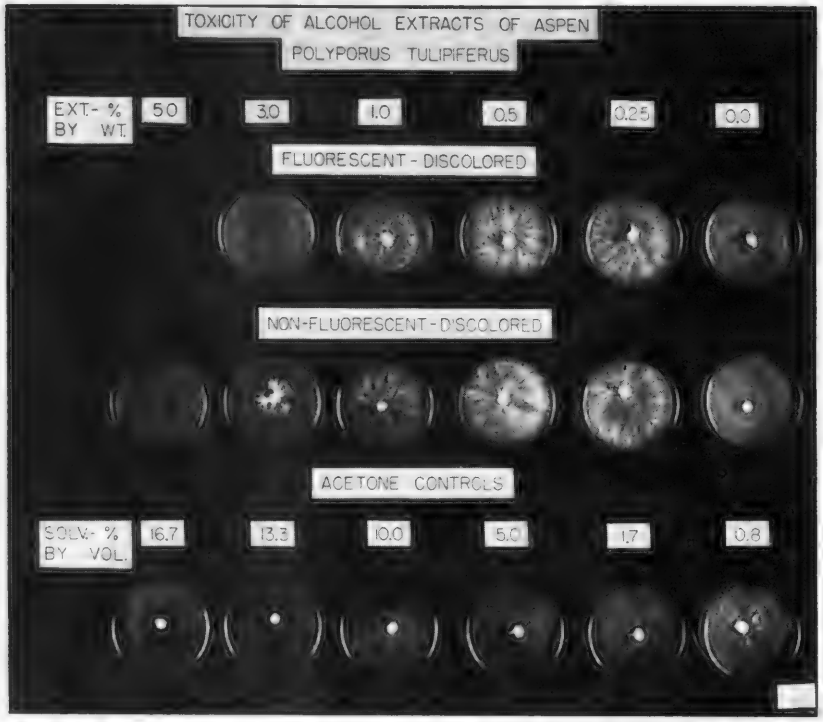


Fig. 9.—The relative growth and appearance, at 14 days, of cultures (*P. tulipiferus*) in a toxicity test of the alcohol extracts from fluorescent and non-fluorescent discolored wood.

was made was non-fluorescent, several weakly fluorescent spots appeared in its extract corresponding to similar, more intense spots in the extract of the fluorescent wood. Most significant, however, was the appearance, in the extract of fluorescent wood, of a large, well-defined, and intense spot of brilliant orange fluorescent material that was not present in the chromatogram of the extract from the non-fluorescent material. The isolation and chemical identity of this component of fluorescent aspen wood and its toxicity to wood decaying organisms are under investigation.

A consideration of the results of this and a previous study gives rise to an interesting speculation concerning the properties of discolored aspen wood as they may be interpreted in terms of a commonly accepted definition of heartwood. It affirmatively satisfies the condition of color, the presence of tyloses, the accumulation of extractives in the ray tissue, and a measure of resistance to attack by several decay organisms. The observation that a peripheral fluorescent zone may be more durable than a central region of deeper discoloration is consistent with the report by Scheffer[4] and others that the outer region of some heartwoods is more durable than the inner, older material. There is disagreement, however, in the fact that the discolored wood is often not centrally located in the stem, and that it is not uniformly occurrent in the stem. Thus the material would be more properly called pathological heartwood, were it not for the fact that it has not been established that it is necessarily associated with the presence of a pathogenic organism.

Conclusion

It is suggested from this study that zones of fluorescent wood which are associated with discoloration in aspen wood contain extractive components some of which are toxic toward wood-decaying fungi. It is further suggested that zones of durable wood which have been observed in untreated aspen fence posts, for example, are coincident with the occurrence of these zones of characteristically fluorescent wood.

[4] Scheffer, T. C. 1949. Decay resistance of black locust heartwood. U. S. D. A. Technical Bulletin No. 984.

Lumber Handling with Fork Trucks and Straddle Carriers[1]

MARVIN B. DICKEY

Ross Carrier Division, Clark Equipment Co.,
Benton Harbor, Michigan

Lumber handling by the unit-load system is discussed. The fork truck and the straddle carrier are the primary pieces of equipment involved. Estimates of operating costs are given.

THIS ARTICLE DISCUSSES general principles of handling lumber by what is known as the "unit-load system" with two primary pieces of equipment—the fork truck and the straddle carrier. The unit-load system of handling has been proved the most practical and economical for almost all permanent lumber installations.

In considering the equipment involved, these points should be remembered: a) The straddle carrier reduces horizontal transportation of unit loads to the simplest and most economical form. Large quantities of materials can be moved with practically no loss of productive time for loading and unloading (Fig. 1). b) The fork truck is designed primarily for the lifting, piling and loading of unit loads of lumber or other materials by mechanical means (Fig. 2). Fork trucks are also used as a transportation medium for short distances, but are not so efficient as straddle carriers for transportation over long distances (Fig. 3). This is because the load must be carried at a right angle to the direction of travel. A properly designed fork truck for yard operation in handling lumber will have approximately 50 per cent of its unloaded weight on the drive wheels, so normal tractive ability can be maintained when the vehicle is traveling without a load.

[1] Presented at the second annual meeting of the FPRS Eastern Canadian Section Ottawa, March 14-16,1955. Revised for publication, 1957.

Fig. 1.—The straddle carrier's ability to pick up and deposit large packages in less than 5 seconds makes it ideal for horizontal movement of unit loads.

Fig. 2.—Fork trucks do a fast job of truck loading and unloading. Some can stack unit loads more than 17 feet high.

Each machine has its definite place. The circumstances surrounding the particular handling problem will dictate whether a straddle carrier or a fork truck, or a combination of the two, will prove most economical. The self-loading and unloading ability of both vehicles is the prime reason for the savings and economies that can be achieved by their use. In the case of the carrier, the time required to pick up or deposit a load is 5 seconds. For the fork trucks, this time will vary with the height of unit loads, but generally will not exceed 5 to 30 seconds.

Cost of Operation

In an attempt to arrive at a definite hourly cost figure for man and machine with the unit-load system, it has been found that the cost per thousand board feet of lumber handled ties in closely with the footage or volume over longer time periods. To be more specific, daily totals rather than hours, or months rather than weeks, provide a more conservative and sound figure from which to estimate a common cost yardstick.

Because the initial cost for both carriers and fork trucks are approximately the same, one cost figure will serve as a rough basis for estimate. A cost figure for the machine of $2.10 per hour includes net price, depreciation, maintenance, gasoline, oil, insurance, and so forth. Wage cost averages $1.80 per hour, so that the total carrier or fork truck hourly rate for man and machine is $3.90. This is a fairly conservative figure. Recent accurate costs obtained from a large steel mill using straddle carriers that cost twice the amount of the average lumber carrier and paying an hourly wage rate of $2.40 indicated that the total hourly cost varied between $5.00 and $6.00.

The cost of movement per thousand board feet handled varies greatly with the size and type of operation and the terrain on which the equipment is employed. For large operations, the cost per movement per thousand board feet is extremely small. One operator reported that, on a volume of approximately 250,000 board feet per day, the complete handling operation from green chain to loading dock, using both carriers and fork trucks, cost 10¢ per thousand board feet.

In smaller operations it is more difficult to obtain accurate cost figures. There are, however, numerous examples of plants that produce from 25,000 to 100,000 board feet per 8-hour day where the cost will range from 20¢ to 50¢ per thousand feet of material handled.

A great many installations have been made that prove very profitable among hardwood lumber manufacturers and furniture manufacturers producing or consuming 5,000 to 25,000 board feet per day. In most instances, the cost of equipment and changes necessary are recovered within a 2-year period.

In one small circle saw mill in Indiana operated by a furniture manufacturer, logs are unloaded from highway trucks by a fork truck. They are separated as to species at this time, and all logs of one kind are placed in the same cold deck. A long, sloping skidway is provided at the saw mill which will hold nearly one-half day's supply of logs. The fork truck is able to supply to the mill all the logs of one species and to keep the mill operating by servicing the skidway three times per day. Since this operator consumes his own product, sorting is greatly simplified at the output end of the mill and no green chain is required. Since many short cuttings are used in the finished product, boards are only edged on one side. The operator feels this lets him pick up extra board feet that would normally be disposed of as scrap.

Lumber is placed on sticks as it comes from the saw. Stickered units are supported on kiln trucks on a sloping track so that one man can easily roll the unit from the mill to where the fork truck can pick it up and transport it to the green storage yard for drying. In addition, the fork truck transports lumber from the green yard, and loads and unloads the dry kilns. Since the mill does not produce the entire requirements, lumber arriving by rail is handled from car to storage to kilns. All lumber stickers are handled in simply designed racks from which they are removed from the package to the saw mill or railroad siding. This entire operation is handled by one man and one 15,000-lb. capacity fork truck, with the exceptions of stickering the lumber and loading and unloading the kilns.

Yard Layout

In arranging facilities for unit-load handling by straddle carrier and fork truck, careful consideration should be given to the yard storage area. Good drainage is important, because the weight of lumber stacked 15 to 20 feet in the air can add up to impressive tonnages. A well-drained area will also reduce the cost of yard surfacing

Fig. 3.—Straddle carriers will travel at highway speeds. They can be used as delivery trucks because they lose no time in loading or unloading.

Fig. 4.—Aisle widths and stacking heights should be planned to make maximum use of both floor space and "air rights".

Fig. 5.—The truck above, equipped with a swing-shift device, can unload 20-foot lumber from boxcars with 15-foot doors.

and road construction. Good roads are advisable, and although concrete or blacktop main arteries are advantageous, they are not essential. The material used for surfacing and yards usually can be obtained at the most economical cost in the local area. In the southern part of the United States, there are many examples of unit-load equipment being operated on dirt and gravel of a firm foundation. A local road engineer or construction contractor can usually give the best advice on yard preparation in a given area.

Special consideration should always be given to heavily traveled main arteries, the area around the green chain, the loading docks, and the area in which dry kilns will be loaded. In the case of the latter, a concrete pad is usually a good investment since this is one point where precision handling is required and uneven terrain greatly slows up the operation of the equipment. In changing a storage yard for unit-load handling, it is usually advisable to completely clear all lumber from one area at a time and make all necessary changes in that area so that operation of the mill will not disrupted. Careful preparation and planning of the yard will pay big dividends in time saved and reduced maintenance on the equipment.

Door heights and widths should be carefully checked at any point in the operation where equipment is required to go inside. To stack a unit load of one-half kiln truck packages four high, a fork truck will usually require a door opening 12½ to 13 feet high. A straddle carrier will usually require an opening from 10 to 12 feet high. In constructing new warehouse space where big outside equipment might be used, a truss-type roof that eliminates as many posts as possible is desirable. A clearance of 22 feet under the truss will take care of the extended heights of practically all big fork trucks now being manufactured with lifting heights up to 17 feet 6 inches. Care should be taken to locate lights and sprinkler systems above this height wherever possible.

In rearranging old sheds, a simple truss usually can be used so that every other post can be eliminated. Special lifting heights for fork trucks can be obtained so that maximum utilization can be made of the converted storage warehouse, and the truck can still do a good job of outside materials handling. (Fig. 4).

Stickering Lumber For Unit-Load System

Careful supervision of yard personnel to see that uniform unit packages are constructed when the unit system is first placed in service will save many future headaches. A simple stickering jig to assure accurate placement of the sticks will help greatly.

Depending on the size and type of the operation, stickering can be accomplished at the green chain, at a separate stickering area, or by a mechanical lumber stacker. When stickering is done at the green chain, the lumber unit can either be removed by a carrier, or the unit load can be placed on kiln trucks or some other device so that it can be rolled away from the chain to be picked up by a fork truck.

Where stickering is done at the chain, it usually reduces the number of sorts for species and grade that can be made at that point for a given length green chain. One advantage is that most yard personnel, other than equipment operators, are kept in one place for easy supervision. The disadvantage is the uneven flow of lumber where a large number of separations are required, since a man must move over relatively large distances to stick the lumber.

A good example of an operation where a separate stickering area is used is the Amos Thompson Corporation of Edinburg, Indiana. A small carrier handling a 48 by 48 unit load is used to transport lumber from the green to the air-drying yard. The mill is located in a congested area in a small town, and unit loads are transported as much as one-half mile. A concrete pad was installed with rails inserted on a slope so that, when a package of lumber is set down on kiln trucks, it can be pushed easily by one man. A roof over the pad gives weather protection, and a stickering jig is suspended from the roof and counterbalanced so it can be raised out of the way for moving the unit loads. The 4-foot units are placed on kiln trucks at one end of the operation by the carrier. The lumber sticks are placed conveniently on each side of the pad for the two men used in the sticking operation, and 6-foot kiln trucks are placed on the track in front of the jig. When the unit package is complete, the men move the

guide out of the way and push the unit out on the track where the fork truck picks it up and places it in the yard for air drying.

The fork truck is also used for transporting lumber from green yard to dry kiln and from kiln to loading dock, and for handling logs that are stored beyond the reach of the yard crane during certain seasons of the year. The carrier's other duty is handling all finished veneer flitches from production to storage and from storage to the car for loading. Management estimates that total outside handling costs have been reduced approximately 50 per cent by use of the unit-load system of handling.

In large operations where a mechanical stacker is used, either the carrier or the fork truck can transport lumber to the stacker. In many cases, a large carrier designed to handle a package 6 to 8 feet wide by 12 feet high picks up the completed unit load, transports it to the yard for air drying and from the yard to the kiln trucks for kiln drying. At one large hardwood mill in southern Arkansas, the unit-load system was installed in which small carriers were used for handling from green chain to mechanical stacker, large carriers were used for handling from stacker to yard to kiln, and small carriers and fork trucks were used in the manufacturing and loading operations. A total of 300 men were replaced.

Loading and Unloading Cars and Trucks

Where railroad box cars are loaded by carrier, a dock should be provided at car floor level or above. The unit load of lumber can then be placed almost inside the door. A fork truck also can be used in approximately the same manner, or, in smaller operations where dock facilities are not available, it can be used at ground level. One installation of this type utilizes an adjustable horse or platform made of steel pipe. The platform is deposited in front of the car door by fork truck and is adjusted to proper height, and a stick rack is placed at the end of the platform away from the car. Lumber is placed on the platform with one end of the package practically inside the car door. The inspector works on top of the package, kicking the sticks in the rack and throwing the cull boards to one side to be repackaged later. One or two men work inside the car placing the lumber in position.

Some installations use a simple, non-adjustable wooden platform placed in front of the car door, and others place one end of the package on the floor of the car and the other end, on a simple wooden horse. Loading solid-bed, roller-bed, or stake-body trucks is relatively simple and can be accomplished easily from either side. Dunnage required for fork clearance can be removed if necessary. The closed van-type truck can be loaded by resting one end of the package on the back of the van and the other end on a horse of equal height and the width of the package. A pusher car constructed of a piece of angle iron and straps is then inserted over the end of the fork so the end of the package may be lifted by the fork truck. The package is then simply pushed into the truck far enough for the doors to close. Six to eight packages can be loaded into a van-type truck by this method.

When unloading box cars where several separations for size, species or grades are required, the straddle carrier is the best machine for moving lumber from the car door, since six to eight separations can be made. With a fork truck used where a large number of separations are required, it will sometimes be necessary to move partially completed units to get completed units away from the car.

Kiln Loading

Where a conventional kiln and track system is used, two or three unit packages are normally used to make a complete kiln load. If the kiln is to be unloaded by a fork truck, it is usual to leave a 4-inch separator between the unit loads. If unloading is to be accomplished by other means, it is possible to remove the separator by the use of two simple wedges on which the second unit load is deposited. The forks are then withdrawn until only about six inches remain under the load. The side of the package is raised and the wedges are removed. The forks are thin enough at this point so that the clearance provided by the standard lumber sticks allows them to come out of the package.

Another method that utilizes a collapsible steel separator is used by several companies and requires less time.

Many dry kilns now in service are designed specifically for lift-truck loading. Here the unit loads usually are stacked four high and three to six deep. Approximately four feet is allowed at front and rear of the kiln for air circulation. All fans and other equipment are located overhead. On kilns of this type, a door 20 to 22 feet high and wide enough to handle the longest lumber to be dried is required. Kilns of this type, however, can be loaded and unloaded faster and with less equipment and manpower than can kilns of conventional design.

Special Fork Truck Attachments for the Lumber Industry

Through the years, many special attachments have been developed to make the fork truck more versatile and economical for unit-load handling of lumber. The following is a brief description of the more important of these attachments:

Side Shift Carriage: Permits the lifting forks to be shifted laterally four to five inches each side of center with full load on the forks. This makes it easier for the operator to line up lumber sticks one over the other when stacking in the green yard and on the kiln truck. This attachment in many cases will permit the operator to do 15 to 25 per cent more work in a given time.

Slope Piler: This attachment is designed to permit lumber to be stacked in the green yard with a pitch of 1 to 1½ inches per foot of length of the lumber. The slope piler was developed for those operators who felt that conventional flat stacking normally required for use of a fork truck caused damage to the lumber in their area of operation.

Combination Side Shift and Slope Piler: This attachment combines the features of the two attachments previously mentioned.

Shovel Attachment: Available for larger fork trucks in 1- to 3-yard capacities. The larger sizes are used by some of the smaller mills and manufacturers for snow removal.

Swing Shift Carriage: This device provides the features of the side shifter mentioned previously with the ability of the forks to swing 15 to 20 degrees each side of center (Fig. 5). This attachment reduces lifting capacity more than a side shift or slope piling carriage.

Pulpwood Loader Attachment: This device was developed by several manufacturers specifically for use in the southern United States for handling pulpwood. It is used in concentration yards, where pulpwood is purchased from numerous small producers, for unloading trucks and loading special cars. The device utilizes slings instead of forks, and can be purchased for considerably less money than the conventional crane previously used for this operation.

Other attachments are available for loading bins and for stacking lumber with the end of the package parallel to the length of the truck. These attachments have been developed primarily for the retail operator who carries smaller quantities of a given item, and needs more separation space in his yard area.

Tree-Length Wheeled Skidding[1]

DONALD W. GRAY

Assistant Woods Manager and Logging Engineer, The KVP Company, Ltd., Espanola, Ont.

The development of a tree-length wheeled skidding program is outlined. Early trials, current developments and future potential are brought out. Findings show that, where forest conditions are suitable, higher man-day production and lower unit costs are obtained.

Introduction

ONE OF THE NEWER DEVELOPMENTS in the mechanization of pulpwood operations in Eastern Canada has been the application of rubber-tired vehicles to skidding.

This report has been prepared to give you a summary of this "new look" in skidding. It is a procedure that, as applied to tree-length logging, has played a major role in the development of the mechanization program at KVP.

The following points and principles will help to introduce the subject:

1) Experience and development has been restricted designedly to the handling of tree-length material rather than short-wood.

2) Skidding is a stump-to-landing operation, and is the most important single phase of the entire production cycle, from the standpoint of the expenditure of labor and money. More man days per cord are expended on this phase than on any other, and at least half of the wood production costs are incurred in this phase. It is a straight materials handling problem. It is in the stump-to-landing area that improved efficiency of operation through mechanization should yield the greatest dividends.

3) In any discussion, there should not be too much concern with the mechanical details of any particular piece of equipment, but rather with the application of equipment of this type to skidding, the effect on operating practices, and improvements in efficiency that have resulted.

4) The method is one that is new and that is still being modified and changed from month to month.

[1] Presented at Session V, Logging, FPRS 11th National Meeting, June 23–28, 1957, Buffalo, N. Y.

The Author: Donald W. Gray has had broad experience in industry and government. Following graduation from the Faculty of Forestry, University of Toronto, in 1930 he joined the Ontario Department of Lands and Forests. He later was with the Abitibi Power and Paper Co. Ltd. as divisional forester, and the Commission of Government, Newfoundland, in charge of forestry, game and inland fisheries administration before joining KVP in 1943. He is a senior member, Woodlands section, Canadian Pulp and Paper Assoc., and a member of the Canadian Institute of Forestry.

Initial Trials

The reasoning that preceded the decision to test the applicability of wheeled units for tree-length skidding went something as follows:

The stump-to-landing phase is the area that requires the greatest expenditure of man hours and labor dollars per unit of production. Within that phase, better than half the expenditure of many hours is for bucking up and piling where pulpwood is produced in conventional lengths of 50 inches or 100 inches.

If tree-lengths could be logged from stump to landing, man hours required per unit of production should be materially reduced. But, if tree-lengths are to be skidded, it would be necessary to mechanize the skidding and replace the horse.

Much of our country was judged to be suitable for the operation of wheeled units in contrast to crawler units, and there appeared to be a good possibility that skidding with wheels would be more efficient than with the various high-lead cable-yarding systems.

To be on the safe side, mechanization should be done slowly, and the soundness of the proposal should be tested step by step to avoid major mistakes.

Initial tests were conducted over a period of two years. In the first test, it was determined that tree-length skidding should be economical. Several types of skidding units were tried, but results were inconclusive so far as indicating the best unit for the job was concerned. Further trials were conducted to obtain more definite results, and at the same time to develop operating techniques and practices that would permit the efficient use of both men and machines. Another most important development of this step was the selling of the new method to the rank and file workmen. A definite interest was shown by a proportion of the men, particularly the younger men.

Results were encouraging and the operation was then expanded to a semi-commercial scale; additional skidding units were acquired and some 8,000 cords were produced by this method over a period of about 6 months. Operations were carried on under both summer and winter conditions, in pure and mixed stands, in timber of large and small diameters, and with some variations in operating practices. The operation was a hot-logging one, with skidding production being delivered to a portable slasher, reduced to pulpwood lengths mechanically, and loaded and hauled direct to the final landing. Again, results were encouraging.

The trials had indicated a need for some modifications in the skidding units. Required changes were discussed in detail with the manufacturers, and arrangements were made to have them revise their specifications accordingly and to incorporate agreed upon changes in the production of new units.

It was then possible to embark on a full-scale trial of the method. This was done during the season of 1956–1957.

Present Stage of Development

A major part of the KVP pulpwood is being produced in tree lengths by means of wheeled skidders—35,000 cords are scheduled for 1957. The operation is being carried on under both summer and winter conditions. Skidding distances have been extended successfully and economically up to 3,000 feet in summer and 4,000 feet in winter.

The operational pattern is as follows: It is a hot-logging job with trees being delivered to a slasher as cut. The cut-and-skid crew is a four-man unit with three or sometimes four such crew units delivering wood to the one slasher. The four-man unit consists of one skidder operator, one chokerman, and two fellers and limbers.

Roads suitable for truck hauling are prepared through the cutting chance in advance, and slasher sites or sets are cleared and bulldozed. A slasher is moved in, and felling starts with the clearing of skidding trails that radiate out from the slasher site to the perimeter of the area to be skidded. Felling proper is then started. Trees are felled with the butt towards the set so that they may be skidded butt first.

Fig. 1.—A load of tree lengths being bunched by winching in.

Fig. 2.—Load assembled with butts lifted into the A-frame ready to skid to slasher set.

Felling starts at the back end of the trail so that men do not have to work in their own slash and tops.

The skidder is essentially a short-wheel-base, all-wheel-drive truck chassis with a winch and A-frame mounted at the rear. Choker assemblies consist of a 5/8-inch main line, some 40 or 50 feet in length, that carries up to seven or eight chokers that slide on the main line on rings. Chokers are 1/2-inch cable, 6 feet in length, with a Bardon hook and ferrule attachment. Each skidding unit is supplied with two choker assemblies. As trees are cut and limbed out, the load is prechoked by the chokerman. The skidder comes in, drops his empty choker assembly, hooks on to the loaded one, and assembles his load by winching in and bunching all the butts into the A-frame (Figs. 1 and 2). The winch is locked and the load skidded out to the slasher (Fig. 3). Loads average three-quarters to one cord.

What results are being obtained? This is perhaps best answered by summarizing the actual 1956 experience.

During the summer and fall period at one camp, 16,500 cords were cut and skidded, with the average skidding distance being 1,100 feet and the maximum 2,400 feet. The stand was a good one on a level to rolling site and gravelly to loamy soils. Jackpine was the predominant species, with a light admixture of poplar and birch and an understory of spruce and balsam. The stand was clear-cut for softwoods and poplar. Trees averaged 6.1 to the cord, and ran as large as 26 inches at the stump and 90 feet in height. Yield per acre was about 45 cords. Production per man day, eight hours, cut and skid averaged 4.64 cords and per skidder hour 2.33 cords. Peak daily productions were as high as eight cords per man day and four cords per skidder hour.

During the past winter on another operation, 1,750 cords of tree-length poplar were taken out. Ground conditions were good, terrain was level, and trees averaged 7.4 pieces per cord. In this case, skidding distance averaged 2,100 feet, and the maximum distance was 4,100 feet. Production per man day cut and skid averaged 4.75 cords, and per skidder hour, 2.54 cords. The average skid was twice as long as on the summer operation, and yet both man and machine productions were higher.

This emphasizes a point that cannot be overstressed—the fact that we are still in the early stages of development in adapting this method to logging problems. It is difficult to be categorical as to present results because they are improving steadily. It is even more difficult to judge what results should be obtainable in the future.

A phase of this operation that is of particular interest is the integration of log and pulpwood production. The slashers are designed to slash any tree into either 100-inch pulpwood lengths or 16 to 18-foot log lengths. In practice, all material that is suitable in size and quality for sawlog production is cut into logs, and only the tops and smaller trees are converted to pulpwood (Figs. 4 and 5. The sawlogs are exchanged for an equal volume of pulpwood with a sawmill firm. In the 1956 summer jackpine operation referred to previously, about 20 per

Fig. 3.—Load arriving at slasher set; it will be dropped about 10 feet ahead of position shown and in line with slasher feed.

Fig. 4.—Discharge end of slasher, showing production of 17-foot sawlogs and 100-inch pulpwood.

Fig. 5.—General view of slasher set, showing skidded tree lengths in foreground, skidding units, slasher and pulpwood being loaded on semi-trailer unit.

cent of the total volume was produced in log form.

This is a step which permits improved utilization of the forest yield, and which is in turn practical because trees are being skidded full length direct from the stump to the landing. An interpretation of the above production factors in terms of wage rates shows a relatively high degree of efficiency, and overall economy of operation.

There are other favorable factors:

1. Being able to skid from the stump for distances of half a mile or more means a material reduction in the mileage of temporary haul or branch roads required for any given chance.

2. The dragging of full length trees from the stump does a fairly good job of disturbing and scarifying the forest floor, and establishes conditions much more favorable for natural regeneration than do manual methods.

3. The amount of bull-work that men must do is reduced to a minimum, which makes it easier to obtain and hold a higher caliber woods labor force.

4. The more or less year-round applicability of the procedure materially lengthens the operating season and again makes it possible to attract better men to woods work.

5. The system is applicable in a wide range of forest types.

6. The system lends itself to hot-logging, which in turn makes it possible to substantially reduce the overall company pulpwood inventories.

7. Utilization of the forest is improved, trees are taken to a smaller top, and there is better utilization of inferior trees than is the case with manual operations. Stands that are not economically available by other methods are available when this procedure is used.

8. Production per man day has been higher and cost per unit of production lower than by competitive methods.

All logging chances are different, and it is not sound to make comparisons of unit productions and costs for different methods except for individual specific cases. Nevertheless, there are variances that it is sound to compare, providing it is understood that the data are comparative and not absolute; that they illustrate trends which are significant but which may not be applicable in specific instances because of local circumstances.

It is in the light that Table I has been prepared. Man-day production, equipment investment costs, and production costs for three alternate procedures are compared with the tree-length, wheel-skid-to-slasher method. Comparisons are based on 100-inch pulp-wood loaded on board trucks ready to haul to the final landing, and necessarily involve not only the skidding but also the reducing to pulpwood length and loading of the bolts.

Probable Future Developments

There are at least two major weaknesses in the present operational pattern as described above:

1. The strict hot-logging nature of the job makes it too demanding and not sufficiently resilient. Skidding production is determined from hour to hour by the cutting production. The skidder interferes with both the chokerman and the fellers, and the feller in turn interferes with the chokerman, and to some extent the skidder.

2. Portable slashers are more expensive to man and operate than are the higher capacity permanent installations.

In 1957, attempts will be made to improve the first of these conditions by breaking the hot-logging phase following the felling and limbing. Trees will be precut well in advance of the skidding, and the cutter will be independent of the rest of the cycle. Choking and skidding will be able to proceed at a rate determined only by the capacity of the skidding unit, and will be freed entirely from hour-to-hour dependence on the cutter. Skidding

Table 1

A. Comparative man-day requirements per 100 cords of 100-inch pulpwood loaded on truck ready to haul to final landing

(a) Fell and wheeled skid tree-length to slasher Slash and load		(b) Cut and pile Bundle yard and load		(c) Fell tree-length cable yard to cold decks Slash and load		(d) Cut and skid with horses to main road skidways Crane load	
Cut and Skid	21	Cut and Pile	37	Fell	11	Cut and Skid	37
Slash and Load	9	Yard and Load	3	Yard	15	Load	2
				Slash and Load	8		
Man days/100 cords	30		40		34		39
B. Approximate equipment investment cost per 100 cords daily (8 hour) delivery							
Skidders	$40,000	Yarder (part)	$16,000	Yarders (3)	$ 60,000	Crane (part)	$ [illegible]000
Slasher(s)	40,000			Slasher(s)	40,000		
	$80,000		$16,000		$100,000		$ [illegible]000
C. Comparative costs on board trucks for direct labor and machine cost and including allowance for variance in cost of temporary roads required							
	$ 8.00		$ 8.50		$ 8.75		$ 9.50

Notes

(a) Highest man-day production; high equipment investment cost; applicable in stands of large or small diameters; maximum road spacing, minimum road cost.
(b) Relatively low man-day production; low investment cost; applicable only in stands that can be cut and piled (small diameters); intermediate road spacing, road cost relatively high.
(c) Good man-day production; highest investment cost; applicable efficiently only in stands of larger diameters; intermediate road spacing, road cost relatively high.
(d) Relatively low man-day production; low investment cost; applicable in wide variety of stands; minimum road spacing, road cost high.

production should increase from 2-½ cords per hour to 3 or even 4 cords without reduction in skidding distance. Felling production should increase, and it seems reasonable to anticipate a cut-and-skid production of 6 cords per man day instead of 4.75.

A second test will be in the loading and hauling of tree lengths to a central point, preparatory to the possible later establishment of centralized processing plants. This again will spell increased man-day production and lower costs if it proves to be a sound development.

To date, as a matter of policy, trials have been confined to relatively favorable ground conditions, so that equipment might be tested, men trained, operational techniques developed, and so forth with a minimum of complications due to adverse topography.

In the winter of 1957 it was found that tree-length wheeled skidding out of swamps is sound and practical if trails are broken out ahead of time and allowed to freeze. In the coming year, operating plans will be adjusted to this pattern, and cutting and skidding will continue through the winter. Swamp areas not available in the summer months will be harvested.

It is expected that tree-length wheeled skidding will be applicable in areas much rougher and more broken than have been tried so far. Some modifications in equipment and operating practices will probably be required, and production per man and machine day will probably be lower. It is in these areas which are comparatively high cost chances by any method, however, that there is a greater margin for cost reduction, and mechanization should pay the highest dividends. Trials designed to test the soundness of this judgment and to determine what modifications are required in both equipment and operating practices are scheduled in 1957.

An increasing number of manufacturers are entering the wheeled skidder field, and 1957 trials will include several different makes of equipment.

Summary

Wheeled skidders are being used successfully by KVP in the delivery of tree-length material from stump to landing. Over a three-year period, techniques, procedures and equipment have been developed and modified to the point where full-scale commercial application of this procedure is being practiced.

Full-length trees are being cut and skidded 3,000 to 4,000 feet, with average daily production rates up to 4.75 cords per man day. Production costs are lower than by competitive methods. The procedure is applicable to a wide range of forest types under both summer and winter conditions. It is silviculturally attractive, and forest utilization is improved. It is proving to be attractive to the workmen, particularly the younger group, because it eliminates much of the heavy manual labor and also because it helps to make possible longer, steadier periods of employment.

The use of wheeled equipment for skidding tree-length material has proven sound and economical. Much work remains to be done to further improve and broaden the application. KVP plans a continuation of their efforts in this direction, including the testing of some of the newer model skidding units now coming on the market.

Discussion

Lowell Besley (Pulp and Paper Research Institute of Canada): You say you feel the need of breaks in your hot-logging system to provide slack. How about the use of pallets behind your slasher to provide such a break?

Mr. Gray: We do not feel the need for any break at this point. We can generally have trucks or trailers available for loading directly from the slasher, and use of pallets would involve a rehandling, which would increase costs.

G. Brodie Gillies (Gillies Bros. & Co., Ltd.): I am interested in the basis of the cost figures you quoted. Are any of your men paid on a piecework basis? What was your write-off rate on machinery?

Mr. Gray: There were no piecework workers on this job. We felt unable to establish a fair piecework rate at the beginning for a new method of operation. Consequently all men were at the established union rates for equipment operators of $13.96 per day, plus an incentive bonus for productivity, which amounted to about $3 per day additional. In addition, workers who provided their own chain saws were paid another to $2 per day for the rental of these saws. The machinery was charged on a rental basis. The rental rate established for the skidding tractors, which includes depreciation and maintenance, was $3.50 per hour.

K. O. Roos (Booth Lumber, Ltd.): You mentioned that you were planning to pre-fell your timber in the future. How about the possibility of your pre-felled timber being covered by an overnight snowfall?

Mr. Gray: We are planning on doing this pre-felling only on summer operations. It would, of course, be too risky during the snow season.

Paul Lane (Lake States Forest Experiment Station): What was the variation in productivity on this operation between winter and summer sessions?

Mr. Gray: Actually, the winter operations were more productive last year. Part of this may have been due to progressively greater efficiency of the crew as they became accustomed to the methods and equipment.

W. R. Warner (Southern Lumber Co.): Was there any difference in productivity between operations in jack pine, aspen, and spruce?

Mr. Gray: Yes. Productivity in spruce was lower because of the greater time necessary to prepare the trees for skidding.

K. C. Compton (State University of N. Y., College of Forestry): Did all men on the crew receive the same daily wage?

Mr. Gray: Yes, except for the power-saw owners as mentioned previously. Actually, more of the men owned saws than were needed on the job. Consequently, one man's saw was used one day, another's the next, and the rental payments were thus distributed among several crew members.

F. C. Simmons (Northeastern Forest Experiment Station): This general subject of skidding with four-wheel-drive rubber-tired tractors is one of the most promising developments in the logging field today. Developmental work on this type of tractor for logging is going forward among the manufacturers, and new models and makes are being announced frequently. There are about 20 different machines available today, ranging from a 4500-pound close-coupled job to giant 23,000-pound and larger machines with integral arch. The machine used by Mr. Gray is in about the middle of this range, both in size and price. Various makes and models of these machines are effecting economies in logging in different forest types, and in kinds of terrain ranging from swamps to steep and rocky mountain slopes. We will attempt to keep you informed of further developments in this field as they occur.

High Pressure Pneumatic Conveying in the Wood Product Industries[1]

WILLIAM C. SMITH

Rader Pneumatics & Engineering Co., Ltd., Vancouver, B. C.

High pressure conveyor systems save time and expense in carrying chips, sawdust and waste products. "Compaction" enables four freight cars to carry the normal load of five. Cost comparisons are presented along with nine operational case studies.

Introduction

A PNEUMATIC CONVEYOR is simply a high velocity air stream that is used to move material from one place to another.

Until only recently, pneumatic conveyors meant low pressure or fan systems. Re-educating mill personnel as to what high pressure can do has been very successful, particularly in the north-west states. As a result, during the last three years, this company has installed about 120 systems in the wood products industry.

Comparison of High and Low Pressure Systems

The basic difference between high and low pressure systems is the means used to provide the required air stream. The high pressure uses a positive displacement compressor while the low pressure system uses a centrifugal or axial flow blower. The positive displacement blower in a high pressure system delivers a constant volume of air regardless of back pressure, but the low pressure fan has a maximum static pressure rating and air output will greatly drop off above its maximum static rating. This difference is illustrated by the curves shown in Figs. 1 and 2.

Low pressure systems have been used for years in the lumber industry as exhaust systems used to pick up sawdust, planer shavings, and similar materials. These systems are not economical as conveyors but do provide a simple means of collecting waste from various points in a mill. They are also vitally important in finishing processes where wood waste must be removed as fast as it is produced to prevent degrading of finished products.

As the means would indicate, high and low pressure systems operate at different maximum pressures. Manufacturers usually rate the maximum static pressure of a fan in inches of water, the average fan having a maximum static pressure of about 12 inches of water or 1/3 psi. The compressors used in a high pressure system, on the other hand, have pressure ratings of 3, 6 or 10 psi. This maximum pressure is very low considering the pressure range covered by various makes of air compressors but, nevertheless, they are high pressure when compared to existing fans. Hence the term, high pressure conveying.

As a conveyor, a high pressure system is much more efficient than a low pressure system and the reason is simply illustrated. As an example, choose a pipe of such length and diameter that when the air is pumped through it at the required line velocity, the air friction or, the free running pressure, is 1/4 psi. Since the maximum pressure of a fan is about 1/3 psi., the amount of the pressure rating of the fan left for doing work is 1/3 – 1/4 or approximately equal to .09 psi. The pneumatic efficiency of this system could then be represented as $\frac{.09}{.33} \times 100 = 27$ per cent. If a 6 lb. blower were used, the pressure left for doing work would be 6 — .25 = 5.75 lbs. psi. and the pneumatic conveying efficiency would be $\frac{5.75}{6.0} \times 100 = 96$ per cent. It is not the intention of this illustration to claim that a pneumatic conveyor will operate at 96 per cent efficiency but merely to show that it is reasonable that a high pressure conveyor can be several times more efficient than a low pressure conveyor.

[1] Presented at the annual meeting of the Northwest Region Sept. 24-25, 1956, in Lewiston, Idaho.

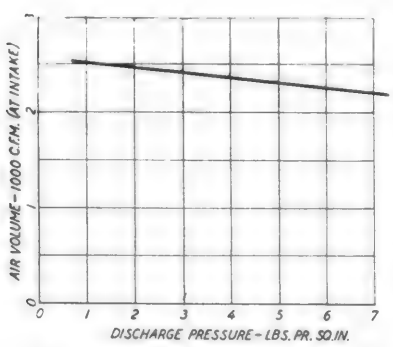


Fig. 1.—Characteristic curve showing output of positive-displacement compressor at constant rpm.

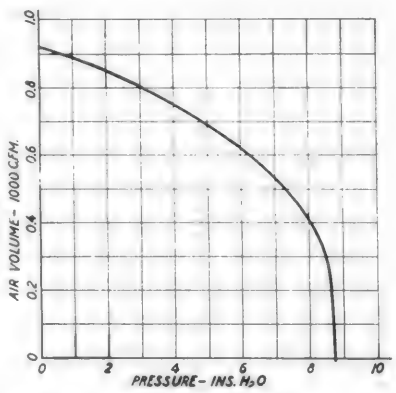


Fig. 2.—Characteristic curve on centrifugal fan at constant rpm.

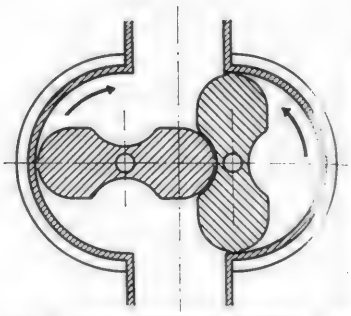


Fig. 3.—Cross section of impellers in a positive-displacement compressor.

Positive Displacement Compressor

The positive displacement compressor has been in general use for many years. Fig. 3 shows a cross-section of such a compressor, Fig. 4 shows the gears which hold one impeller in its proper place with respect to the other.

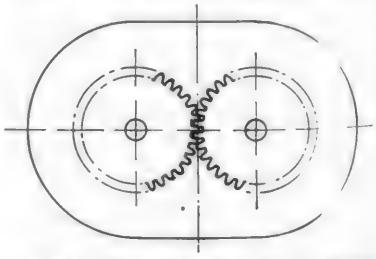


Fig. 4.—End view of positive-displacement compressor showing gearing of the impellers.

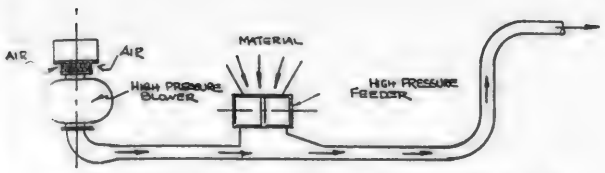


Fig. 5.—Schematic diagram showing material injection into a high pressure system.

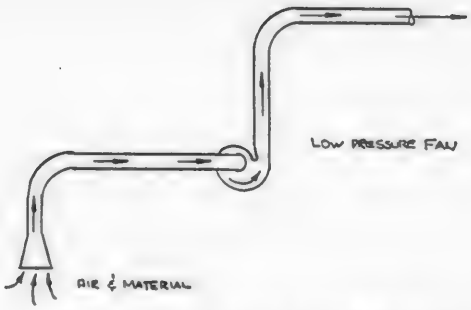


Fig. 6.—Schematic diagram showing material passing through a low pressure fan.

In this illustration, if the right hand rotor or impeller is driven in a counter-clockwise direction, then the left hand impeller will be driven in a clockwise direction. Air will be drawn into the rotor chambers at the bottom, carried around the rotor chambers and squeezed out from between the rotors as the rotors mesh on the top. If this direction rotation is reversed, air will enter the top and will be discharged at the bottom. The clearances between these rotors, and between the rotors and housing, are only a few thousandths of an inch.

These minute clearances account for another basic difference between high and low pressure systems. In high pressure systems, material cannot be drawn through the blower but must be injected into the air stream by a feeder (Fig. 5). In low pressure systems, on the other hand, fan wheels are especially designed so material can pass through them (Fig. 6). This clearance, or timing as the manufacturers call it, is set when the gears (Fig. 4) are installed in the factory.

Generally, blowers are made with operating pressure ranges of 3, 6 and 10 pounds psi. This rating is a characteristic of the design of the blower, and varies with the ratio of rotor diameter to rotor length. For instance, a 12-inch blower with a rotor length of 12 inches may have a maximum pressure rating of 10 pounds, a 12-inch blower with a rotor length 20 inches long may have a pressure rating of 6 pounds, and a 12-inch blower with a rotor 30 inches long may have the maximum pressure rating of 3 pounds.

Theory of Pneumatic Conveyors

The theory behind pneumatic conveyors is basicly simple. It is not the purpose of this paper to go into the methods or formulas used to calculate the requirements of a pneumatic system, but merely to discuss it in a very general way.

In designing a pneumatic conveyor, first of all the rate of flow, type of material, horizontal and vertical distance, and number and degrees of bends must be established. Knowing these points, the second step would be to select (from experience) the most practical conveying velocity and to calculate the material losses or the work done in pumping material through the pipe. The third step is to choose a pipe size so that the maximum pressure will not exceed the pressure ratings of the blower to be used and, finally, the horsepower required is calculated.

When air alone is flowing through a pipe, the back pressure or gauge pressure at the blower indicates the air-to-line friction that is present. This is referred to as the free running pressure. As material is introduced into the line, the pressure rises. This rise in pressure indicates the work being done in conveying material through the line. When a system is properly designed, the total operating pressure, which equals the free running pressure plus the rise in pressure due to material, should not exceed the manufacturer's maximum pressure rating on the blower.

Why Use a High Pressure Conveyor?

In the wood industry, the reasons for choosing a high pressure conveying system over a standard belt or chain conveying system would fall into two categories.

1. Problems involved in installation.
2. The use of the high pressure conveyor for some feature as well as conveying.

Installation: Here the high pressure system solves many problems. Most sawmills which been in operation for several years are finding now that revenue from waste utilization is becoming more and more important. This is a new phase in sawmill operation and, as a rule, mills were not originally laid out with this in mind. If a chipper is to be installed and the chips conveyed either to trucks, rail cars or scows, in many instances the location of the chipper is at one side of the mill and the loading point at the other. When compared to the installation of a conventional conveyor, it is extremely simple to run a pipe under or through a mill to the discharge point. If the conveyor must go through a mill storage area, the pipe can be suspended on poles, on 40 to 50 foot centers, at whatever height is required for operating clearances. The cost of installing a pipe on poles or bents is very small compared to the installation cost of a conveyor and gallery. Another good example is the conveying of chips to the top storage silos which may be as high as 100 feet. Other than simple brackets and poles, no other construction is required to support the pipe. A conventional conveyor, on the other hand, would require large galleries and trusses, which are costly.

Pipe may be strung under or over roofs, curved around obstructions, buried in the earth, suspended over a yard on either existing supports or by cable. It can go over or under roads and railroad tracks, can be suspended over water and, if properly dipped and wrapped, can be laid under water.

If more than one point of discharge is required, manual valves or remote-controlled automatic valves can be installed. Even with the larger pipe sizes, the latest designs of valves are counterbalanced so they can easily and quickly be handled by one man.

Special Application: Here the advantages of a high pressure conveyor are numerous. Consider an installation to build an outside storage pile approximately 100 feet wide x 300 feet long and 40 feet high. With a high pressure system, a simple deflector can be put on the end of the pipe and a very large pile can be built with no further handling. When the initial pile is built, more pipe can be laid across the top of this pile and the pile can continue to grow until the storage area is completely filled. Compare the cost of 200 or 300 feet of pipe to a mechanical distributing system and it is very easy to justify the installation of a high pressure system.

As a second example, a system is desired to load chips into box cars. Material is picked up at some place in the mill and conveyed to the loading point. Here, by means of either a deflector or specially designed loading hood, material is blown into the box cars. By blowing material into a car, from 20 to 40 per cent more material can be

Table 1.—TYPICAL LOADING RESULTS WITH HIGH PRESSURE LOADERS

Assume—(1) Volume of Average West Coast Chip Car = 4,000 cu. ft. = 20 units.
(2) Material—Average Fir Sawmill Chips—18 lbs./cu. ft. = 3,600 lbs./unit.
(3) Moisture Content—50% of Green Weight.

	Uncompacted Loading	Compacted Loading
Weight of Green Material in Car	20x3,600 = 72,000 lbs.	Actual Wt. 100,000 lbs.
Weight of Bone Dry Material	36,000 lbs.	50,000 lbs.
Bone Dry Units Per Car = Bone Dry Weight / 2400	36,000 / 2,400 = 15	50,000 / 2,400 = 20.8
Compaction = Bone Dry Units / Car Volume (Unit)	15x100 / 20 = 75%	20.8x100 / 20 = 104%

$$\text{Increase in Pay Load by Weight} = \frac{100{,}000}{72{,}000} \times 100 = 39\%$$

$$\text{Increase in Pay Load by Compaction} = \frac{104}{75} = 39\%$$

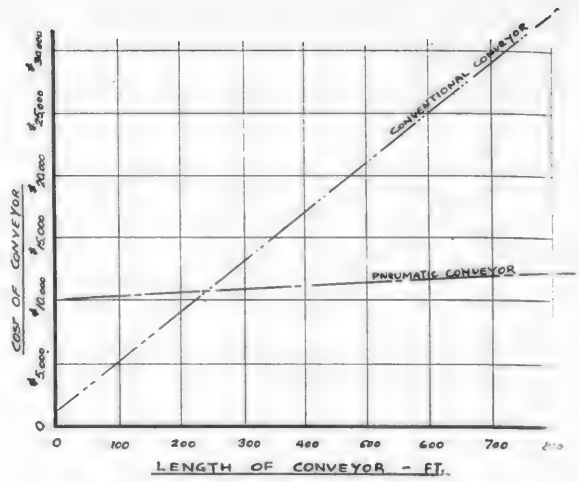


Fig. 7.—Comparing costs of a pneumatic conveyor with a conventional conveyor.

pumped into each car. On the West Coast, mills equipped with the latest loading hoods are now filling open top cars with a weight of chips almost equal to the load rating of the railroad car. If, for instance, 25 per cent more material can be pumped into a car, only four cars need be shipped instead of five, and since the freight rates on chips are charged on a per car basis rather than per ton, the cost of shipping chips automatically drops 20 per cent per ton. In many instances, the freight savings alone will pay for the high pressure system in six months or a year of operation. Where chips are being loaded into closed top box cars, the cost of manually loading a car and packing chips tight up to the roof would be tremendous. This is done automatically with a high pressure system and no labor whatsoever is involved.

Compaction

One Volumetric Unit = 200 cubic feet

One Bone Dry Unit = 2,400 lbs. bone dry wood

The term "compaction", now widely used on the west coast, originated in pulp mills and is used to compare the actual pay load of chips in a railroad car to a set standard. In establishing the standard, moisture content, variation in size of car, and degree of packing were to be accounted for. It was originally thought that under ideal conditions, maximum loading would be reached when 2,400 pounds of bone dry wood were packed into each 200 cubic feet of volume in the car. This degree of loading would be called 100 per cent compaction. Later developments in loading devices have now increased loading efficiency to the point where cars loaded with sawmill chips will have average compaction ratings of 105 per cent and cars loaded with veneer chips will have average ratings of 108 per cent. Extreme conditions will often result in figures as high as 115 and 118 per cent.

Perhaps the best way to illustrate the effect of compaction loading is to compare results for typical installations (Table 1). For average conditions, mechanical loaders will get between 15 and 18 bone dry units of chips into a railroad car but high pressure loaders will pack approximately 22 bone dry units into the same car.

Table 2 shows typical freight savings when using high pressure loaders based on freight rates in the Portland area.

Table 2.—FREIGHT SAVINGS WITH HIGH PRESSURE LOADERS

Miles Hauled	Freight Charge Per Car	Freight Charge Per Unit For 17 Unit Load	Freight Charge Per Unit For 22 Units	Savings Per Car
360	$230	$13.52	$10.45	$67.60
260	175	10.29	7.95	51.45
180	140	8.23	6.36	41.15
140	100	5.88	4.54	29.40

Note: The above table was based on freight rates in the Portland area.

In order to take full advantage of compaction, most west coast pulp mills receiving chips by rail have put compaction clauses into their chip buying contracts and have installed moisture samplers and weigh scales at their unloading stations.

Longview Fibre Co. in Longview, Wash. was the first to conduct tests to find the advantages of compacting chips. Potlatch Forest Inc. in Lewiston, Idaho, was the first to take advantage of this feature by installing several high pressure loading systems in surrounding mills.

Cleanliness is an important feature of a high pressure system, particularly when handling dusty material. The system is completely enclosed from end to end and can therefore eliminate the possible fire hazard caused by dust settling in conveyor galleries and mill buildings.

When strung in the open, the pipe itself needs no cover or roof over it and therefore does not require any gallery or sprinkling system, etc.

There are no moving parts between the ends of the high pressure system and therefore no maintenance is required. This is a decided advantage in the case of a conveyor three or four thousand feet long.

It is very true that a high pressure conveyor takes much more horsepower than a conventional conveying system but, if reduced initial installation costs and extra advantages are considered, then a high pressure conveyor is easily justified and is a profitable investment.

Comparing Costs with Other Conveying Equipment

It is very difficult to give reasonable figures for comparing the cost of high pressure conveyors with the more conventional types of conveyors. As an example, consider a typical air system. Assume the blower and feeder will cost $10,000. If the length of the conveyor is 200 feet, and pipe cost $2.50 per foot, then total cost is $10,500. Cost per foot is then $52.50. If the same conveyor were extended to 600 feet, the total cost would be $11,500 and the cost per foot would drop to about $19.20. In other words, the longer the conveyor, the more practical an air system becomes.

A conventional conveyor, on the other hand, has almost a uniform cost per foot regardless of length. If typical costs were plotted, then a breakeven point would appear between 200 and 300 feet of length (Fig. 7). This breakeven point will favor an air system even more as the number of changes of direction and the change of elevation of the conveyor increase.

It is also both difficult and dangerous to quote the horsepower per ton figures for a given distance which

would be required in a high pressure system. There are so many variables in each pneumatic installation that each system must be individually designed. As an example, however, to convey approximately 3000 cubic feet per hour of wood chips a distance of 500 feet would require 60 to 75 horsepower.

Recent Developments

With a quickening of interest in high pressure conveying and in the compaction feature in particular, the problems inherent in high pressure conveying systems soon began to show up. The most difficult problem was that of introducing material into a high velocity high pressure air system. Conventional air lock or rotary type feeders were not satisfactory since they could not cope with oversized material and were not able to withstand constant abrasion. This is probably the main reason why high pressure conveyors had never become popular in the wood industry.

Chipper type knives were built into feeders to handle the oversized material and all surfaces subject to abrasion were made of alloy steels (Fig. 8).

These new feeders have proved themselves in the field and are now being used with great success on chips, screened and unscreened, and hog fuel.

Some feeders incorporate a positive method of venting returned air and can therefore be used on lighter materials such as planer shavings and sander dusts. Another good feature of some feeders is that the air stream passes below it and not through it. As well as cutting down actual wear in the feeder, this allows any number of feeders to be put in a line. Material can be picked up at several places in a mill and can be removed with the one conveying system (Fig. 9).

Loading Hoods

Shortly after the first compaction tests were run by the Longview Fibre Co., an extensive test program was started to find just how maximum compaction could be obtained. It was found, for open top cars, chips had to be loaded in uniform layers across the length and width of the car.

The compaction results from these methods can best be shown by specific example. Before high pressure systems were used, chips were loaded into cars

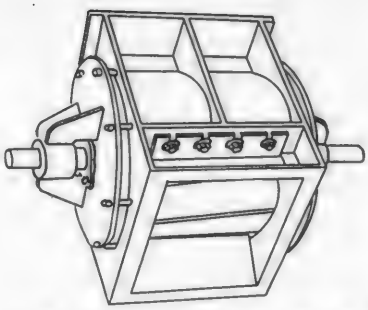


Fig. 8.—Rotary star feeder used for introducing material into pressurized air stream.

by overhead belt or chain conveyors. The actual weight of chips loaded into a car would run from 65,000 to 70,000 pounds. With compaction units, this pay load has increased in many cases to as high as 110,000 pounds.

Valves

Diversion valves are another important accessory to the high pressure conveying system which have been extensively developed. These valves, of course, become necessary when more than one point of discharge for material is required. Quick-acting manually operated valves which can be easily operated by one man, and automatic valves which can be used for remote control operations were developed. These valves are available in all pipe sizes used for conveying.

Designing a High Pressure System

1. **Rate of Flow:** There are a few precautions to take when installing a high pressure system in a mill. The first and foremost is sizing the system correctly. A high pressure system cannot be overloaded and must be sized with a good factor of safety to account for any future increases in production. A study should be made to determine existing and future material production and then these figures should be checked with data available from comparable mills.

2. **Metered Flow:** In the average chip system, when bad logs are going through the mill, production rate is at its highest. If the maximum rate that chips are being produced is compared with the average weekly production, then peak rates of flow will be four or five times greater than average rates of flow.

The most practical way to lay out a system, therefore, is to install a small surge bin to receive the chips from the chipper. Chip flow can now be metered from the bin on to the screen and into the high pressure feeder. This initial metering allows the screen and the high pressure system to work at maximum efficiency. Screens will not even out a large surge of material. It takes such a short time for material to cross a screen that, if a surge lasts longer than a few seconds, the screen will be overloaded and good chips will carry over into waste conveyors.

Even if a screen is not required, the surge bin and metering device is still vitally important to the high pressure system. If a surge bin is installed in a system and the capacity of the surge bin is approximately 25 to 30 per cent of the hourly production, then the high pressure system can be designed with a rated capacity of 25 per cent over the average hourly production. For instance, if the expected average hourly production is eight tons per hour of green chips, and a surge bin is installed to hold approximately two and one-half tons, the high pressure system, if designed to handle ten tons per hour of green chips, will be adequate. These are minimum conditions and should only be used when material production is uniform. If material can build up in conveyors and large surges can be produced, then the size of both surge bin and pneumatic system should be increased accordingly.

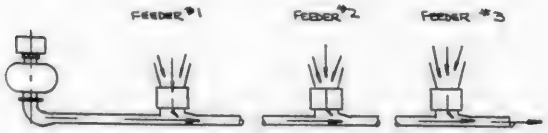


Fig. 9.—Schematic diagram showing multiple injection. Three feeders in one conveyor line.

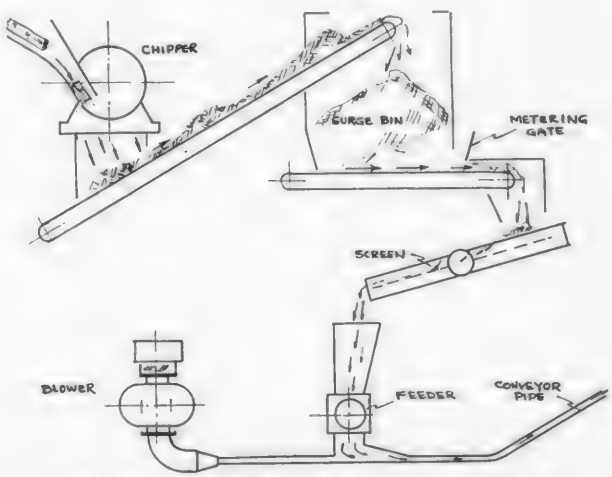


Fig. 10.—Schematic diagram of typical chipping system.

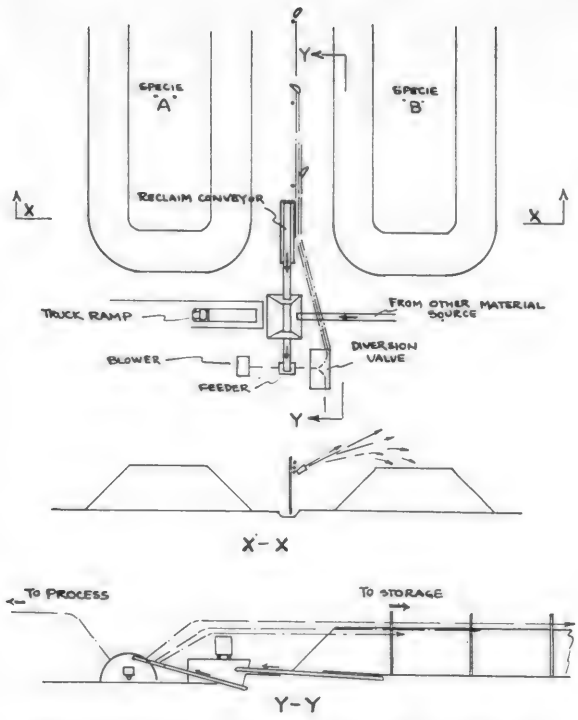


Fig. 11.—Schematic diagram. Typical outside storage and reclaiming system—separation of species.

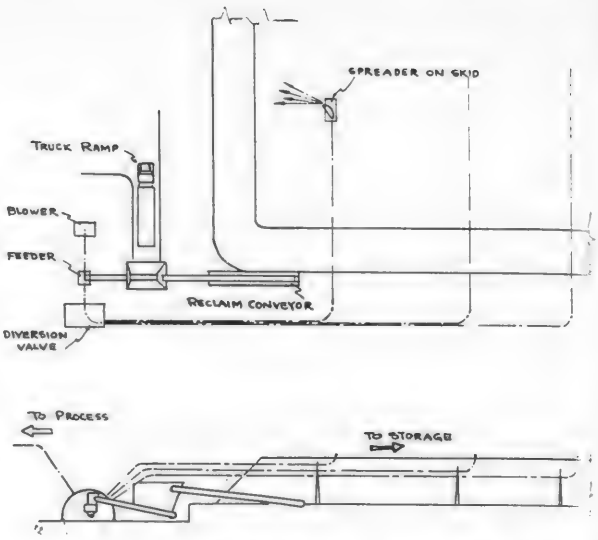


Fig. 12.—Schematic diagram. Typical outside storage and reclaiming system—one specie.

The cost of a system with a surge bin to handle a metered flow will usually be much less than a larger system to handle peak flows.

If the type of material to be handled by the high pressure system is free flowing or granular, the high pressure feeder can be used to meter the flow of material. In sawmills, however, this is not the case. Material is not free flowing and is not uniform in size. In order to reduce wear on the feeder and to avoid continual shearing of material, the feeder should be designed to run between 40 and 70 per cent full. This is particularly important in the case of chips and will practically eliminate damage to the chips. This will perhaps explain why the feeder in a sawmill installation should not be expected to meter the flow of material.

3. **Control:** With a surge bin in operation, material is metered before it reaches the high pressure system and, theoretically, the maximum rate of flow should never be exceeded. However, as an extra precaution, a simple control arrangement can be installed in each system to prevent overloading. This is done by wiring pressure-operated switches into the control circuits of both feeder and feed supply motors. If the pressure in the system rises above normal operation, these switches will open, stop material flow, allow the system to clear, and then automatically restart the motors again.

4. **Velocity:** Most engineering handbooks contain tables showing minimum conveying velocities required for wood products. It is not recommended that a system be designed to operate at this minimum velocity. It is good policy to apply a factor of safety here to help offset such conditions as intake filters getting dirty, belts getting slack and slipping, and occasions when material much heavier than specified does get into the system.

5. **Factors of Safety and Over Design:** Compared to the total cost of a chipper system in a sawmill, the high pressure system is a relatively small expense. Any tendency to undersize the high pressure system would be false economy. The high pressure system is the final link in a long line of equipment and if, due to unexpected production, it becomes overloaded, the output of the complete chipping installation is restricted.

6. **Pipe:** It is wise to use heavy wall pipe, both in straight pipe and in bends. The cost of increasing the thickness of the straight pipe in the original installation is very small compared to that of replacing it. Another factor is that heavy wall pipe may be supported at much greater intervals than thin wall pipe.

Actual wear in straight pipe is very slight but this is not the case wherever bends or elbows are put into a line. Use much thicker-walled pipe in the bends. In most normal systems, where heavier walled pipe has been used, the life of the bends should be several years.

What is the Scope for High Pressure?

The greatest use for high pressure systems in the wood industry has been in the movement of chips. However, more and more systems are being installed to convey mill refuse such as hog fuel, bark, sander dust, shavings or sawdust.

One question which is repeatedly asked is, "how far can you blow material?" Theoretically, there is no limit to distance but, from a practical standpoint, the maximum economical distance appears to be in the neighborhood of 5,000 to 6,000 feet.

Perhaps the best way to illustrate the uses of high pressure systems is to describe briefly some installations.

(1) This system conveys about 120 units of chips per eight hour shift from the sawmill to the storage silos, total distance 4,700 feet. One man controls wood flow into the chipper and another worker is required at the weight scales on top of the silos. The pipe for this system was laid on piles alongside the railroad tracks and went underwater in the Columbia River spring flood of 1956. This system has never stopped operation.

(2) Chips conveyed from sawmill 500 feet to loading station. By means of a valve system, eight open top cars can be loaded without being moved.

(3) This is a triple injection system, picking up chips at three points throughout the mill and conveying them to a scow. All the pipe through the mill for this job is buried beneath the mill floor. (Fig. 9)

(4) A double injection shavings system. Two feeders are used to gather all waste produce in the planer mill.

Six units per hour conveyed 900 feet to fuel storage.

) An hydraulically controlled telescopic loader packs up to 50 units per hour of chips into hatch top cars. This system was installed primarily to increase the weight of chips per car.

) Two 40 unit per hour systems convey chips either to silos, to the screen room, or to one of two outside storage piles.

These examples are but a few of the special applications where high pressure is meeting the needs in the wood industry. It is somewhat amazing to look back at the development in this field during the last two or three years.

Conclusions

This paper has briefly described a few of the uses of high pressure conveyors in the wood industry. The examples are but a few special applications. Firms with a material handling problem, should investigate high pressure conveying. It does have a lot of answers.

Effect of Several Production Variables on Modulus of Rupture and Internal Bond Strength of Boards Made of Green Douglas-Fir Planer Shavings[1]

J. W. TALBOTT
and
T. M. MALONEY

Junior Wood Technologists, Division of Industrial Research, Washington State Institute of Technology, Pullman, Wash.

The effect of resin content, wax content, and specific gravity on strength of particle boards made from two screen fractions of green Douglas-fir planer shavings was studied. In some cases, the effect of the wax exceeded the effect of resin in contributing strength to the board. The internal bond test was found to be worthwhile in interpreting observed results.

Introduction

GREEN PLANER SHAVINGS as compared to other fine mill residues, are believed to embody a number of particle characteristics that have come to be regarded as important for maximum strength in a board. Large and flake-like in general appearance, they are relatively undamaged pieces of wood with a high proportion of feathered edges, which encourages good felting of particles. Despite the fact that each particle contains some very short grain and has some curl, they appear to have much merit as a raw material for some types of boards. For this reason, they were selected for further study of their response to various manufacturing variables.

Of immediate concern in this study was the difference between the effect of the larger shavings and that of the smaller particles that are largely formed by breakage of the larger shavings. These differences might be associated with such factors as the geometry of the particle, its grain structure, surface-weight ratio, and thickness-length ratio. These factors, in turn, control resin efficiencies, compaction characteristics, and the ultimate strength of the board.

In this type of particle board, virtually all the strength is derived from the bonding action of the resin added. Because of the shape of some particles and because of the character of the surfaces, a portion of the resin is not effective in contributing strength to the board. A clew to the effectiveness of the resin is provided when the resin content is varied and the effects on strength properties are noted.

Wax added to particle boards is intended primarily as a moisture-repellent agent that lends dimensional stability to the board under use conditions involving fluctuating humidities. Wax normally is considered to be an inhibitor of the vital adhesive actions required for maximum strength. Stability, therefore, is acquired at the expense of strength. That this is not always the case is one of the most surprising results of this study.

Specific gravity has long been known as a potent factor in its effect upon the strength properties of boards. This effect stems directly from the consolidation pressures associated with specific gravity which, in turn, exert a two-fold influence on the internal structure of the board. One of these influences is related to the bonding actions of the resin and the other to the compaction of the mass of material. It is conceivable that the magnitude of the effect would vary with different particle types or screen fractions.

The most common method of measuring the strength properties of boards is by subjecting specimens to bending stresses and calculating a modulus of rupture value. The principal advantage of this method is its simplicity, while it chief disadvantage is the fact that it measures only a thin line of material across the specimen and is therefore greatly influenced by local variations in the board. An important, but less common, method of measuring strength is in tension perpendicular to the surface, frequently referred to as internal bond strength. This method yields a value based on four square inches of material, but has the disadvantage of being a cumbersome test to run in the laboratory. A further characteristic of this method is the fact that it is more sensitive to the quality of bonds between particles and to factors that produce layering effects in the board. Both measurements obtained together on the same boards were expected to supply further information on utility of these methods in studies of this type.

Procedure

Description of the Shavings The wood particles used in this work were green Douglas-fir planer shavings from an Inland Empire mill. The material was received from the mill at a moisture content of 26 per cent, and was first dried to a moisture content of approximately 5 per cent. After the material was dried, it was screened to produce three fractions, the coarser of which were retained as follows:

1. Retained on 4 mesh screen,
2. Passing 4 and retained on 16 mesh screen, and
3. Fines passing 16 mesh (discarded).

The +4 fraction contained occasional chips up to 1/8 inch thick and up to 1½ inches long. Most of the

[1] Presented at the Joint Meeting of the Inland Empire and Pacific Northwest Sections, FPRS, Lewiston, Idaho, September 24-25, 1956.

particles of the +4 fractions had one or both ends tapered in thickness. The large particles had some curl but usually not enough to cause them to fold back on themselves when pressed. Due to the geometry of the planing operation, the typical large particle had one thin tapered end with the grain parallel to the surface. The thickness increased toward the other end, with the grain direction becoming more inclined to the particle surface. The surface was much rougher toward the thicker, cross-grained end, which terminated in a comparatively abrupt taper along the grain. The —4+16 fraction contained many particles formed by the breaking up of the cross-grained ends of the larger particles.

Description of Additives The resin used was "Durez" 10650 powdered phenol formaldehyde resin.

The wax used was "Paracol" 600N acid-stable water emulsion, infinitely dilutable.

Preparation of the Boards Two boards ¼ by 10 by 10 inches were formed and pressed for each combination of the following factors:

2 screen fractions:
+4 and —4+16
3 specific gravity levels:
0.60 0.75 0.90
3 wax levels:
0% .75% 1.5%
3 resin levels:
2% 4% 8%

This made a total of 108 boards. For each combination of screen fraction, wax level, and resin level, two batches of the proper fraction of shavings were weighed out, each of sufficient amount to form one board at each of the three specific gravity levels. Each batch was then placed in a rotary drum mixer and sprayed with the calculated amount of wax emulsion diluted with enough water to bring the final moisture content of the mix up to a uniform 10 per cent on the basis of dry wood. In batches calling for 0 per cent wax, plain water was sprayed in to adjust the M.C. to 10 per cent and also to duplicate in some measure the advantage shared by boards with wax in picking up the powdered resin in the mixer. The appropriate weighed amount of powdered dry resin was then immediately added to the charge, and the mixing was continued for 5 minutes. The material was then weighed out in proper amounts for individual boards of the three densities, sealed in individual polyethylene bags, and held for later pressing. This procedure greatly increased the efficiency of the laboratory operation. Each combination of variables, therefore, was represented by two boards, each from a separate batch, which provided adequate control of a major source of experimental error.

The boards were formed by hand by means of a deckle box and a 10- by 10-inch steel mold. The formed mat in the mold was then covered with a top caul and pressed in an electrically heated press at a temperature of 325° F. Sufficient pressure was applied to bring the board to caliper in 3 minutes, and the board was then held at caliper for 3 more minutes for a total press cycle of 6 minutes. An unexpected observation during the pressing procedure was that both increasing the resin content and increasing the wax content lowered the pressure required to bring the boards to caliper in 3 minutes at a given specific gravity. The pressure required varied from 210 psi for the low-density, high-wax, high-resin boards, to 750 psi for the high-density, no-wax, low-resin boards.

Preparation of Test Pieces After the boards were pressed, they were cooled and trimmed to 8- by 8-inch size, and two 2- by 8-inch M.O.R. test pieces were cut from each board. A 3- by 8-inch piece was also cut for use in a later study of dimensional stability characteristics of this series of boards. All the test pieces were then conditioned for 132 hours in a controlled atmosphere at 70° F. and 50 per cent relative humidity before they were tested.

Testing Procedures After the thickness of the M.O.R. specimens was measured, they were broken in bending on a Rhiele universal testing machine according to A.S.T.M. procedures. The span was 6 inches and the head speed was 0.12 inch per minute. The crosshead motion was stopped as soon as the load had obviously passed its maximum value, rather than allowing it to proceed to complete failure. This reduced the distortions in the area of the break, and permitted a more accurate specific gravity correction.

To improve the precision of the M.O.R. measurement, a correction for off-center breaks was applied. If, due to lack of uniformity of the material, the break did not occur at the center of the span, the distance (x) from the break to the nearest support was measured and recorded to the nearest 0.1 inch. The M.O.R. as computed by the standard formula was then corrected to correspond to the actual bending moment existing at the location of the failure by the following formula:

$$\text{Corrected M.O.R.} = \frac{(\text{Standard M.O.R.})\ (x)}{\frac{1}{2}\ \text{span}}$$

A further refinement in correcting M.O.R. measurements was introduced by a change in the method of determining specific gravity. Instead of measuring the specific gravity of the entire M.O.R. specimen, only the material in the actual area of the break was used. The specific gravity tab was 1 by 2 inches, and was cut so as to include the break.

The specific gravity correction for M.O.R. was made by plotting a curve of M.O.R. against specific gravity for each combination of screening fraction, resin content, and wax content. The ordinates of each of these curves at the nominal specific gravity values of 0.60, 0.75, and 0.90 were read and recorded as the average M.O.R. values characterizing the corresponding combinations of production variables.

After the specific gravity tabs were cut from the M.O.R. test pieces, an adjacent 2- by 2-inch tab was cut from each piece as a test piece to determine the tensile strength perpendicular to the surface, or internal bond strength. Specific gravity values for these tabs were also determined. The surfaces at the tabs were given a light sanding, after which they were cemented between aluminum test blocks conforming to A.S.T.M. Specification D1037–55T, using "Chemotec" 805 epoxy resin cement. An excess of catalyst was used to accelerate the rate of cure and permit testing within 5 hours at room temperature. The assemblies were then pulled apart in tension at a head speed of 0.02 inch per minute. The maximum load was recorded and divided

Table 1.—AVERAGE MOR VALUE FOR 2 SCREEN FRACTIONS, 3 SPECIFIC GRAVITY LEVELS, 3 RESIN LEVELS, AND 3 WAX LEVELS

Per cent resin	Per cent wax	+4 Fraction, Specific gravity 0.60	+4 Fraction, Specific gravity 0.75	+4 Fraction, Specific gravity 0.90	—4+16 Fraction, Specific gravity 0.60	—4+16 Fraction, Specific gravity 0.75	—4+16 Fraction, Specific gravity 0.90	Av.
2	0	570	1120	1740	370	860	1720	1060
	0.75	890	1550	2040	580	1320	2030	1470
	1.5	750	1410	2480	500	1060	1860	1340
4	0	750	1400	2500	650	1270	2270	1470
	0.75	1020	1700	2860	810	1360	2470	1700
	1.5	1080	2060	3470	780	1460	2440	1880
8	0	1060	1780	2860	850	1670	2800	1840
	0.75	1300	2080	3380	1080	1880	3120	2140
	1.5	1310	1980	3630	1000	1980	3140	2170
	Av.	970	1680	2820	740	1430	2430	

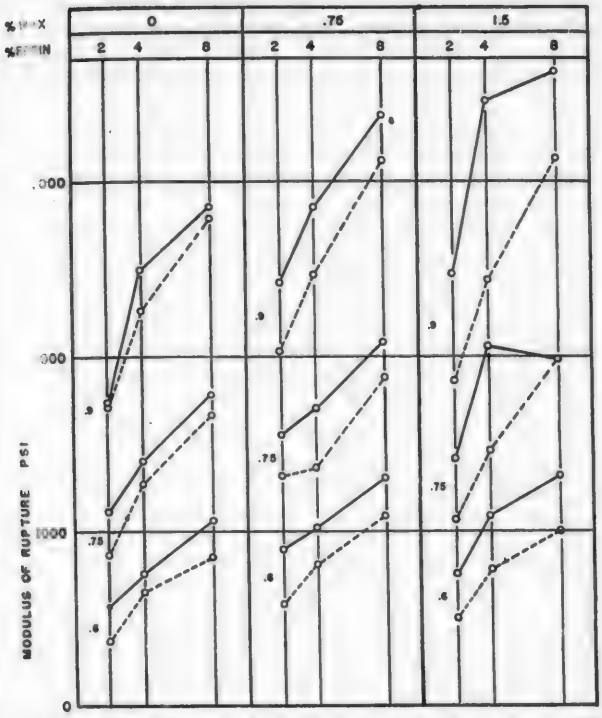


Fig. 1.—Effect of wax and resin on modulus of rupture at specific gravity values of 0.60, 0.75, and 0.90. Full lines represent the +4 screen fraction, dotted lines the —4 + 16 screen fraction.

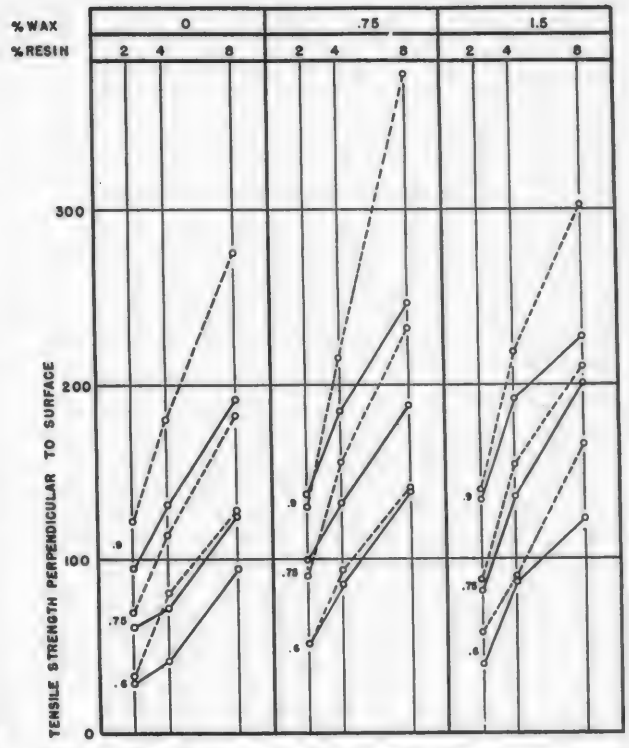


Fig. 2.—Effect of wax and resin on tensile strength perpendicular to surface at specific gravities of 0.60, 0.75, and 0.90. Full lines represent the +4 screen fraction, dotted lines the —4 +16 screen

by the area of the block to give the tensile strength perpendicular to the surface in psi. These values were plotted against the previously determined specific gravity values of the test pieces, and the ordinates of the curves at 0.60, 0.75, and 0.90 specific gravity were recorded as the average values of the internal bond strength of the material for each of the combinations of production variables.

Results and Discussion

The average M.O.R. values corresponding to the various combinations of screening fraction, resin level, wax level, and specific gravity level are presented in Table 1. The same values are presented in the diagram, Fig. 1, as three families of curves of M.O.R. against resin content.

The values of tensile strength perpendicular to the surface are similarly presented in Table 2, and in Fig. 2.

Modulus of Rupture The average M.O.R. values ranged from 370 psi for low-density, low-resin, no-wax, fine-particle boards, to 3630 psi for high-density, high-resin, high-wax, coarse-particle boards.

The main effect of screening fraction on M.O.R. was that the +4 fraction boards are consistently stronger than the —4+16 fraction boards. This superiority was probably related primarily to the higher length-thickness ratio of the +4 fraction particles rather than to particle size as such, although the higher surface-weight ratio of the —4+16 fraction also contributed to the effect because of the leaner resin distribution per unit surface area.

For reasons not immediately apparent, the strength difference of the two fractions was also enhanced by increasing the wax level, but was relatively unaffected by resin level.

The main effect of resin was an increase in M.O.R. with increasing resin. This increase, however, was not in proportion to the resin content. For all wax levels, density levels, and screening fractions, the average M.O.R. values were:

2% Resin ------ 1290 psi
4% Resin ------ 1680 psi
8% Resin ------ 2050 psi

The M.O.R. gain from 2 per cent to 4 per cent resin was 390 psi, or slightly greater than the gain of 370 psi that occurred from 4 per cent resin to 8 per cent resin. This represents a marked reduction in resin efficiency, and is in accord with expectations. The gain in M.O.R. from increasing the resin content was greatest at higher density levels and higher wax levels, while it was approximately equal for the two screening fractions. With the +4 fraction at the .9 specific gravity level, however,. the additional resin from 4 per cent to 8 per cent had a very low payoff in higher M.O.R. This was probably because, at these conditions, the 4 per cent resin level produced sufficient bonding between the flake-like particles of the +4 fraction to result in tensile failure of the particles instead of shear failure of the resin bonds at the particle interfaces. The additional 4 per cent resin under these conditions was therefore impotent to contribute to further strength as measured by M.O.R. This was also verified by the character of the M.O.R. failures, which showed abrupt rather than delamination breaks.

Table 2.—AVERAGE TENSILE STRENGTH PERPENDICULAR TO THE SURFACE FOR 2 SCREEN FRACTIONS, 3 SPECIFIC GRAVITY LEVELS, 3 RESIN LEVELS AND 3 WAX LEVELS.

		+4 Fraction			—4+16 Fraction			
		Specific gravity			Specific gravity			
Per cent resin	Per cent wax	0.60	0.75	0.90	0.60	0.75	0.90	Av.
2	0	29	61	95	33	70	122	68
	0.75	51	99	137	49	89	129	92
	1.5	39	81	133	58	88	139	90
4	0	42	73	131	82	114	180	104
	0.75	85	132	185	94	155	215	144
	1.5	87	135	192	90	153	218	146
8	0	94	125	191	128	182	276	166
	0.75	139	188	247	140	232	378	221
	1.5	122	201	226	168	210	302	204
	Av.	76	122	171	93	144	218	

The effect of wax level on M.O.R. presents an unexpected and complex picture. The main effect of an increase from no wax to 1.5 per cent was a gain in M.O.R. from 1460 to 1800, or 340 psi. This is an average gain of 227 psi per 1 per cent of wax, compared to an average gain of 95 psi per 1 per cent of resin. This gain in M.O.R. with increased wax was more pronounced in high-density boards and medium-resin boards of +4 screening fraction. Indeed, the average M.O.R. for 0.90 specific gravity, coarse fraction boards at 4 per cent resin and 1.5 per cent wax was 3470 psi, while that for the same boards at 8 per cent resin and 0.75 per cent wax was 3380 psi. This indicates that, in this region, the addition of the extra 0.75 per cent of wax was actually worth more strengthwise than the extra 4 per cent of resin. Also in this region, the peak of strength benefit from increased wax content was not yet reached at the 1.5 per cent wax level. In low-density, low resin boards, especially those of the —4+16 fraction, this peak apparently occurred at the 0.75 per cent wax level.

The main effect of specific gravity on M.O.R. was, of course, a marked increase in M.O.R. with increasing specific gravity. Within the density range included in this work, there appeared to be an accelerating influence in regard to the M.O.R. gain with respect to increasing specific gravity. In other words, the plotted M.O.R. against specific gravity curves were all concave upward in the entire specific gravity range from about 0.57 to above 1.0. This exponential M.O.R. gain with increasing specific gravity was slightly more pronounced in the +4 fraction than in the —4+16 fraction boards. This is shown in the following tabulation, which presents the average M.O.R. values for the two fractions at the three density levels.

	+4 Fraction	*—4+16 Fraction*
0.60 Sp.Gr.	970	740
Diff.	710	690
0.75 Sp.Gr.	1680	1430
Diff.	1140	1000
0.90 Sp.Gr.	2820	2430

Tensile Strength Perpendicular to the Surface The average tensile strength perpendicular to the surface, or internal bond strength, varied from 29 psi to 378 psi. The pattern of variation of internal bond with resin, wax, density, and screening fraction differed markedly from the M.O.R. pattern.

It was interesting to note that the effect of screening fraction on internal bond was the reverse of its effect on M.O.R. The internal bond strength values of the —4+16 fraction boards were all substantially higher than those of the corresponding +4 fraction boards, with the exception of the low-resin, medium-wax boards, where the relation was reversed. The supremacy of the fine-particle boards in this respect was increased with increasing resin content and increasing density.

The main effect of resin level on internal bond was a nearly proportional gain in internal bond strength with increasing resin. This gain was greatest for higher density boards, for medium-wax boards, and —4+16 fraction boards. As measured by internal bond strength, added increments of resin gave a good account of themselves throughout the range of the experiment. This contrasted sharply with the M.O.R. situation, where the strongest boards benefited very little from resin above 4 per cent.

The effect of wax on internal bond was similar to its effect on M.O.R. The internal bond strength benefit from wax addition was greater with increasing resin and with increasing density. One of the most interesting results of this study was that, in the coarse-particle boards, the average gain in internal bond strength from the addition of the first 0.75 per cent increment of wax was considerably greater than the average gain resulting from doubling the resin content from 2 per cent to 4 per cent. In the 2 per cent and 8 per cent resin boards, the wax benefit to internal bond strength was greatest at the 0.75 per cent wax level, but in the 4 per cent resin boards there was a further small average strength gain with the second 0.75 per cent increment of wax. The reason for this ability of the 4 per cent resin boards to be benefited more strengthwise by higher wax levels than the 2 per cent or 8 per cent boards is not apparent, but it is reflected on both the M.O.R. and internal bond values.

The main effect of specific gravity on internal bond was, as expected, an increase in strength with increasing density. With the coarse-particle boards, equal increments of density yielded equal increments of strength: the relation was a straight line function. With the fine-particle boards, however, the curves of specific gravity against internal bond were mostly concave upward, and successive density increments gave increasingly greater strength gain. The effect of specific gravity was enhanced by higher resin and by the addition of 0.75 per cent of wax.

Comparison of Modulus of Rupture with Internal Bond Strength Measurements It was quite evident from the results that the internal bond test and the modulus of rupture measured different factors involved in the integrity of the boards. For example, in comparing the effect of screen fractions averaged over all conditions of manufacture, the two strength measurements responded as follows:

	M. of R.	*Int. Bond*
+4 Fraction	1820 psi	123 psi
—4+16 Fraction	1530 psi	152 psi

These data reveal that the finer screen fraction exerted a negative influence on modulus of rupture while giving the internal bond strength about a 23 per cent boost. The explanation of this seeming paradox is not too clear because the improvement in internal bond for the finer fraction had to come about in spite of decreased resin concentration on the surfaces. This leads to the possibility that the geometry of the smaller particles might have been such as to provide increased contact areas for effective bonding on planes that resist tensile forces perpendicular to the surface.

Conclusions

The following conclusions may be drawn from the results of this study:

1. The coarse screen fraction yielded higher modulus of rupture values than did the fine fraction at all levels of resin and wax content.

2. When strength was compared by the results of the internal bond test, the reverse was generally true; the fine fraction gave the higher strength.

3. The addition of 0.75 per cent of wax had a beneficial effect on both strength properties under all conditions of resin content, specific gravity, and screen fraction. In some cases, the effect of the wax exceeded the effect of resin in contributing strength to the board. This was particularly true with the coarse screen fraction at 2 per cent resin content.

4. The effect of resin followed the usual pattern of increase in both strength properties, but there was evidence of decreased resin efficiency with the 8 per cent resin content.

5. The internal bond test was found to be a worthwhile adjunct to the modulus of rupture test in interpreting the observed results.

Editor's Note:

Some of the questions left unanswered by this research formed the basis of a subsequent project under the sponsorship of the Hercules Powder Company of Wilmington, Delaware. Much broader in scope, this project will seek to answer the basic question regarding the specific role of wax additives in boards, both from the standpoint of strength and from the standpoint of moisture resistance. Also included in the experiment are a number of wax types, various sequences of application, and both liquid and powdered forms of urea and phenolic resins.

The results of this study will be made available through the Forest Products Journal in the near future.

Some Practical Aspects of Particle-Board Core Stock

DEAN E. SCHMIDT

Practical aspects of the production of particle board for core stock are presented. Various cost factors are considered in relation to competition and the economic benefits of a "captive" plant set-up where the bulk of the output is already sold.

MUCH HAS BEEN WRITTEN about particle board and the relative merits of the various processes available. The purpose of this article is to pass on to the reader some of the points to consider before putting in a particle board plant, and in the selection of the method of manufacture.

By late 1957, the manufacturers of particle-board core stock are going to find themselves in a highly competitive market. The rapid increase in new installations will temporaily, at least, exceed the development of new markets. For this reason, a group considering one of the currently available installations should have the following two features available:

1) A sufficient, continuing, uniform supply of scrap wood available on the premises, and 2) the plant should be operated in direct association with a plywood or furniture operation that will use the cores made. The first of these is important because it may prove difficult to produce particle-board cores competitively with wood purchased from various local suppliers. Points that must be considered in evaluating a locally purchased wood supply are:

1) The cost, availabality and grades of such wood will be variable with the seasons and the weather.

2) The storing and handling of sufficient inventories of scrap wood of various sizes and shapes is a large expense or a continuing headache. (Compare this operation with a plant that already has large quantities of scrap wood available and is already handling it. In all probability, the scrap wood can be delivered directly to the particle board plant with no handling charge at all.)

3) Variation in wood species and moisture content will make each day a different manufacturing problem, regardless of the process used.

4) The suppliers of raw material cannot always be prevailed upon to keep the product free of foreign materials such as tramp metal, dirt, glass, stones, and so forth. The particle board manufacturer must consider that some impurities will get into the chips in spite of the care taken. A mill tied to a woodworking plant can be assured of a fairly uniform, cheap and clean source of chips. Such a plant will save as much as 1¢ per foot [1] in wood cost and handling over the plant that depends on outside sources for raw material.

Manufacturers of raw particle board for sale as a core are probably in for a dog-eat-dog era of competition with only the hardy surviving. This premise would make this kind of an investment unattractive unless the investors have a new technological development that puts them far ahead of the competition. It is for this reason that a proposed particle board core-stock plant would best be a captive plant with the bulk of its output already sold.

Another factor that a captive plant can consider is that, at times, a plant using its own core could utilize its low-grade or reject cores in non-critical areas. The plant that makes cores for sale as such will have a sales problem for any factory "seconds" that will develop.

Fundamentally, there are two basic processes in use today in the United States: The multi-platen or hot-press board, and the extruded board. There is a definite place in the industry for both types of board. Each has its advantages and limitations compared with solid lumber cores as well as with the other.

Costs of Manufacture

Particle board cores are meeting wide acceptance today primarily because they can be produced at a lower cost than can solid cores. In comparing the cost of manufacturing such cores, the reader would be well advised to consider the various operations involved and to compare each process for its own merits, and not to use the overall costs of existing plants that use particular processes. For this purpose, the basic operations and expenses of production are broken down and discussed below:

Cost of Woodwaste: This can range from ½¢ per ft. used by some plants that charges wood in at its fuel value, up to as high as 1½¢ per ft. for plants that buy their wood on the open market.

Cost of Feeding Wood Waste to the Process: Here again, some plants have no charge for this service because the scrap was fed to the boiler before the particle-board operation was put in. A plant that buys the wood may require two men or heavy mechanization expense to bring the wood into the plant.

Amortization: The extruded processes should probably carry a heavier burden here than the platen process. For reasons discussed later, the chances of obsolescence will be greater in the extrusion processes.

Drying of Chips: This operation must be considered separately, because a chip dryer is not necessary in a plant where an adequate supply of kiln-dried wood scrap is available. If a dryer is necessary, the cost of drying the chips may run as high as 1¢ per ft.

Labor Cost for Manufacturing the Board: In comparing the labor costs, consider why each process uses the number of men they do. Quite often, one process may appear more efficient due to a greater amount of mechanization that is not inherent in the basic process. For example, the use of an automatic cut-off saw in a particular extrusion process saves the use of a man. However, since an automatic device of this kind can easily be built for any extrusion process, this saving is not inherent to the process.

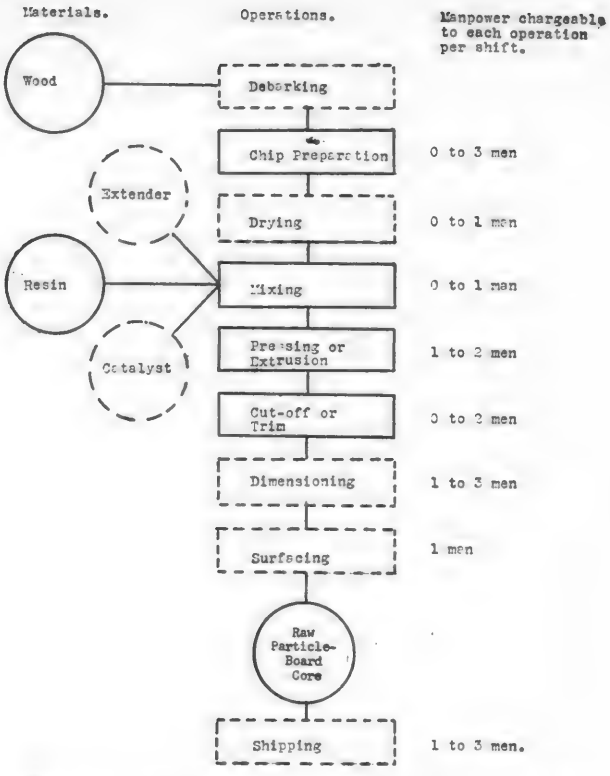
Resin Cost: The cost of the resin, and indeed of all the raw materials used, will depend on the density of the board produced. It would be wise to compare the quality and the density of the product in making a comparison of costs. The resin cost may be the largest single expense a particle-board manufacturer will have. The machinability, strength, water absorption and other physical properties of the board are dependent on the resin content as well as the density of the board.

Commercial particle-board core stock has been made with densities as low as 30 and ranging up to near 60 lb. per cu. ft. (Sp. Gr. range from about 0.5 up to 1.0). The per cent of resin solids used can range from less than 2 to more than 10. The lower ranges on both density and solids are frequently used in European countries.

Overhead and Hidden Costs: The practical businessman investor in a particle-board plant must consider that his costs will run higher than those popularly quoted. These quoted figures must be considered as the optimum performance for the operation, and a goal that can never quite be attained. In many of these guess estimates, such

The Author: Dean Schmidt was formerly Plant Manager for The Dixie Chipboard Co., Rural Hall, N. C.

[1] Based on 3/4-inch thick board at a density around 40 lb. per cu.ft.



Note: Dotted lines indicate materials or operations that may not be used or may not be chargeable to the operation under certain circumstances.

Fig. 1.—General flow chart for manufacturing particle-board core stock.

items as fuel, electricity, maintenance, overhead, sales expense, research and development, and clerical detail may conveniently be forgotten or absorbed by the parent organization of a captive plant. All of these items are legitimate operational costs, and they will increase the cost of the product well beyond the rosy sales picture usually presented. The current processes in operation in the United States cannot market their core stock at a cost running much less than 10¢ per sq. ft. This figure does not include any allowance for profit.

Process Selection

After considering the various problems involved and having made the decision to put in a particle-board plant, the method or process to be used must be decided upon.

If cost of the product is the sole consideration, the extruded board will show to best advantage. Generally speaking, the extrusion processes will make the board cheaper and with more easily controlled density and thickness.

On the other hand, the multiplaten processes are more flexible and more adaptable to changes in resins, chip size and shape, and other variables. Experimentation and new developments are easier to come by in the hot-plate press. For this very reason, many of our wood technologists and research men, as well as the resin manufacturers, favor the multiplaten processes. They are able to produce desired results quickly and easily in the laboratory without losing valuable production time and endangering expensive equipment. There are no laboratory-size extruders available today for testing work.

A direct comparison of the features of the two processes are listed below:

First Cost: Generally speaking, plants of the same capacity and with the same features and degree of mechanization run about the same. Sometimes, local features as existing buildings may favor one process over the other.

Flexibility of Manufacture: The multiplaten process has the lead here. A purchaser of extrusion equipment should plan on amortizing his equipment in 5 years if the law permits, as an insurance against obsolescence.

Control of Manufacture: The continuous nature of the extrusion usually makes control of density, uniformity and thickness of the product better or easier than the multiplaten process. Utilization of product: The extruded board lends itself to cut-to-size cores better than the platen board because: a) it is conveniently cut to width as it is extruded, while the platen board comes in the size of the press; and b) the extruded board lends itself to edge-gluing better, because it is more stable in thickness. This is of importance only when it would be objectionable for a core joint to photograph through the face veneer.

Manufacturing Problems: Extruders are more sensitive to changes in moisture content, resin content, type of resin and catalyst, wood species and chip size than are the platen processes. In making changes during the manufacture of extrusion board, care must be taken against sudden increases in friction of the chips in the curing zone or serious mechanical damage could result. It should be noted here also that, as in other wood gluing operations, the moisture content of the chips is extremely important.

Machinability of Board: The platen board, generally speaking, lends itself more readily to machining, and gives somewhat smoother cuts with less pull-out. In some cases, however, it may be possible to veneer extruded boards without any surfacing operation, because of accurate thickness control.

Photographing: For fine face veneers, some dimpling or photographing of chips will almost always appear in time in the high-gloss finishes used today. Generally speaking, this show-thru will not be either serious or any more objectionable than the variations that will appear in the surface of a product with solid or plywood cores.

The joints of particle-board core to lumber will almost always show up in fine face-veneered furniture. This is due, of course, to the difference in expansion in thickness of particle-board and lumber with changes of moisture content. The multiplaten board will usually show its joints more than the extruded board, because it is subject to a much greater variation in thickness with moisture content than is the extruded board.

The manufacturer of particle-board core stock must be prepared, as new markets develop, for complaints by users not familiar with the proper techniques of veneering such cores. Many of these complaints will not be justified, and the user of the core (whether veneered or not) will often expect a higher standard of performance than he did using his former product.

Many manufacturing problems have fallen by the wayside, as improved machine design and increased know-how have ironed out many of the bugs in the various processes. The development problems are still with us, but they are being partly supplanted by a highly competitive market. The newcomer to this field must be prepared to cope with both.

The Importance of Proper Chipping[1]

GEORGES MASSÈ

Director of Research and Development, Guilliet Co., Auxerre, France

A new machine has been developed that can chip a wide range of raw materials but produces chips of even dimension that permit even penetration of liquor. Although output is considerably less than that of conventional chippers, quality is greatly improved and costs are lower.

Introduction

THE ACCELERATED EVOLUTION and rapid expansion in the industrial use of wood particles has focused the attention of technicians and manufacturers of wood fiber products on the problem of obtaining the most suitable chips or shavings.

The industries use wood particles in a wide range of products, from boards to moulded cases, from furniture to paper pulp, and each has its special needs as to the size and shape of the wood chips. The quality of the final product depends largely, if not entirely, on the type of chips used.

In the manufacture of boards, for instance, experience has shown that the greatest strength is obtained by gluing together fairly large and flat chips of even thickness. The proper arrangement of these chips is achieved by means of a machine that assures an even distribution of the wood fibers in all directions.

A close examination of the product actually reveals a "microscopic" plywood. With chips cut along the fibers, the strength is obviously improved and the necessary amount of binding material can be reduced to the favorable figure of below 8 per cent.

Whenever wood particles are used for moulded products, an important point must be borne in mind: wood is an organic substance that must retain its natural structure. Therefore, when processing wood, care should be taken to avoid pressures that may crush and damage it. If precautions are taken, the final product will have nearly the same density as the wood used.

Conventional Chippers

The conventional chippers now used in the pulp industry, produce chips that are some 1 to 2 inches long, about ¼ inch thick, and from ½ to 1 inch wide. These coarse chips are obtained with these machines by crushing, shearing, and splitting. Consequently, they do not have the uniformity and the constant thickness of chips cut along the fibers. Besides, they are cut on the bias and present crushed ends, because the wood fragments are strongly compressed by the cutters just before they are sheared. As a result, the fibers are partially damaged, and the medullary canals, through which the liquor is supposed to penetrate during the cooking operation, are more or less closed at both ends of the chips. A rapid and even penetration of the liquor cannot be achieved by capillarity alone, therefore, and pressure must usually be applied.

New Development

The engineers of Guilliet in France, aware of the actual and potential advantages of thin and uniform chips in many industries, have come up with a new and versatible chipping machine. It can process any wood of some length, at least one foot, for instance but otherwise without limitation as to the shape; it can process pieces from one to 14 inches in diameter, round or square in shape, and yet preserve the wood fibers.

The chips produced by the machines with a given set of cutterheads are almost identical in dimension, for instance 1 inch long and 1/64 inch thick. The liquor can easily penetrate them not only through the ends and the capillaries, but also by an osmotic exchange on the surface, which acts much more rapidly than capillarity, especially if the wood used is still green.

Besides, in very thin chips composed of a few layers of fibers, the lignin that coats the fibers is much more easily impregnated and softened up.

Attention was called to the advantages of thin chips in 1952 by a study made by the paper pulp authorities Dr. Rys, G. Aron, and W. Overbaeck. Their report was published under the auspices of the F. A. O. (Tropical Wood and Source of Pulp). This research showed that the customary chipping damages a certain proportion of the fibers, while the tests made with chips properly prepared by hand at the time indicated a marked gain in the technical characteristics of the pulp obtained from them.

Since then the same kind of thin chips, cut parallel to the fibers, are produced in a mechanical and economical way by the Guilliet chipping machines.

Tests conducted by the French Government Research Laboratory for Tropical Woods have also shown that chips produced by the machines contain practically no damaged fibers. Indeed, a careful check found less than 1 per cent of injured fibers.

Working Principle

The reason for these good results is the working principle of the machines. The rotating cutters attack the wood parallel to the fibers, that is in the direction of least resistance, and practically peel off the chips. The tools rotate and the wood remains stationary.

The knives wedge themselves between the layers of fibers. Thus the chips, which have been separated and not cut, do not present a strictly smooth surface. The practically intact fibers covered with lignin can be clearly seen protruding on the surface by microscopic examination or even through a good magnifying glass.

Chips produced by the machines were also tested by the Centre Tech-

Fig. 1.—The Guillet chipper, as shown here, is placed in a pit to bring the hoppers to a convenient height.

[1] Presented at Session XI, Wood Composition Board, FPRS 10th National Meeting, June 3-7, in Asheville, N. C.

The Author: Georges Massé first joined the Guilliet Co. in 1931 after graduation from the Ecole Nationale des Arts et Métiers at Châlons-sur-Marne. In 1935 he became manager of a large furniture company. He was a prisoner in Germany during World War II, after which he managed saw mill and forest exploitation operations until rejoining Guilliet as research and development director in 1954.

nique du Bois in France. The samples were 2/10 mm. (8 mils) chips obtained from birch.

Because of the thinness of these chips, the question was whether they contained a considerable proportion of cut or damaged fibers since the cutters could not be expected to attack the wood strictly parallel to the fibers. Three lots of 10 chips each were tested. Schultze's maceration method was applied—nitric acid, plus some crystals of potassium chlorate, the solution being brought to a boil and the chips soaked in it for a few minutes.

The microscopic examination of the separated elements indisputably confirmed the fact that almost all of the fibers had remained intact; the damage amounted to less than 1 per cent. In each of the three lots, the lengths of 100 fibers were measured. The lengths found varied from 400 to 1,500 microns, with an average of 1,000 microns or 1 mm.

Birch wood was chosen because this species had already been the object of basic studies made by the same laboratory. The average length of the fibers had been ascertained to be 710 microns for the fibers near the center of the logs, and 1,051 microns in outside layers (wood formed around the twentieth year of growth). The extremes were 480 and 1,150 microns in the first case, 730 and 1,350 in the second case. The values found in the chips therefore turned out to be quite normal, and the effect of the chipping on the length of the fibers was negligible (less than 1 per cent).

Barking

With these machines, the bark is practically pulverized in the process of chipping by the violent impact of the cutterheads, and it can easily be separated from the chips by a simple sifting operation. The best results are obtained with a specially designed plansichter, because the chips have to be literally "rubbed" on both sides to eliminate all bark dust. A slight amount of bast, which consists mainly of hemi-cellulose, may be found at the edge of some chips, but the corky part of the bark is reduced to dust.

Thus in many applications it becomes unnecessary to bark the wood before chipping. This is true primarily in the cases of semi-chemical pulp and of cardboard pulp. Even for bleached pulps, the traces of bark that remain after chipping can often be eliminated properly either chemically at the cost of a slightly higher consumption of chemicals, or mechanically with adequate strainers (centri-cleaners). In any case, these operations are definitely less costly than preliminary barking, especially so in the processing of brushwood with its strongly adhering young bark.

Fig. 2.—French-developed chipper (shown here without exhaust hood) produces economical, uniform chips, but in relatively low volume.

Even when the bark does not need to be eliminated, as, for instance, in the making of pulp for corrugated cardboard, the separation of the bark from the chips by means of a plansichter is of interest because bark requires less liquor than wood, its separate treatment leads to a saving on liquor, and both the bark and the wood can easily be mixed together again at a later stage of the process.

It is also worth mentioning that the Guilliet chipping machines are specially valuable when woods of greatly different specific weights and hardnesses are mixed, a condition frequently encountered in tropical forests, for instance. In this case, the chips obtained with conventional chippers vary too much in size and shape because the shearing action differs with the physical characteristics of the various woods. But because of the high speed of their cutterheads the machines produce uniform chips, no matter how many different kinds of wood are processed concurrently.

Thin and regular chips, as obtained with the machines, offer the possibility of simplifying considerably the cooking operation, especially for semi-chemical pulps. Since the liquor penetrates the chips easily, rapidly, and evenly, the cooking can be shortened substantially. There are no slivers left; no cellulose fibers are damaged by excessive cooking, and the cooking can be designed as a continuous operation at atmospheric pressure—even a chemical treatment without the use of heat at all may be advantageous.

Industrial installations that make use of these new possibilities have already been built in France and elsewhere. It seems that particularly for hardwoods, cold processes such as a cold soda process or the Delbay nitric acid process have great potentialities. They will permit the erection of even small or medium-size pulp mills at a remarkably low investment and a very economical operating cost.

Three-Ton Production

The new chipping machines, which are intimately linked with these developments, are capable of producing up to three long tons of thin chips per hour in dry weight, and require only some 50 hp. Patented all over the world, these chippers operate on the following principles:

A shallow pan rotates at low speed on an axis inclined at a 45-degree angle. This speed can be regulated from 2 to 10 r.p.m. by a simple device. On the underside of the pan, and symetrically opposite on each side of the center, two electric motors are mounted with parallel shafts, each ending on the upper side of the pan in a cutterhead with a diameter of about 15 inches. These two cutterheads have the same speed as the motors (3,600 r.p.m.) and describe a planetary motion.

Any piece of wood placed parallel with the general axis of the machine, perpendicular to the pan, that is, will butt by its own weight against the latter. When the wood is within the area swept by the cutterheads, at each passage they will cut chips parallel to the fibers of the wood. The length of chips depends upon the height of the cutterheads used.

In the MAF model, which is designed for fairly regular logs, the wood is fed by gravity into hoppers that are subdivided in compartments roughly fitting the diameter of the logs. In the other model, called MAG, irregular wood, even brushwood or mill residues, can be chipped because the pieces are held in place and pushed down the hoppers to the cutters by means of compressed-air clamps. The production capacity is about the same in both models, but, to get the best results, care should be taken in selecting the type of machine.

Since the specific characteristics of wood differ not only according to the species, but even according to the regions where it was grown, it can be seen that expert advice is needed to get the maximum yield and the best product. With appropriate cutterheads and a correct setting, one machine can produce nearly any kind of chips or shavings and even wood flour.

The Building Research Institute and the Building Research Advisory Board[1]

HAROLD HOROWITZ

Technical Secretary, Building Research Institute, National Academy of Sciences—National Research Council, Washington, D. C.

The differences in functions and organizations of BRAB and BRI are noted—BRAB serving primarily in an advisory capacity for Federal agencies, while BRI is a technical society for the building industry. The various programs of each group are illustrated.

Introduction

THE BUILDING RESEARCH INSTITUTE and the Building Research Advisory Board are relatively new in the building industry. However, both are part of a much older organization which has a firmly established role in the leadership of scientific endeavors in the United States, the National Academy of Sciences–National Research Council. The NAS–NRC is a private, non-profit corporation dedicated to the furtherance of science for the general welfare, and is required by its charter to act as scientific advisor to the Federal Government.

The National Research Council includes ten divisions: Anthropology and Psychology, Biology and Agriculture, Chemistry and Chemical Technology, Earth Sciences, Engineering and Industrial Research, Mathematics, Medical Sciences, and Physical Sciences, Office of International Relations, and Office of Scientific Personnel. These divisions conduct their work through permanent boards and institutes, committees, subcommittees, panels, and ad hoc groups for specific tasks. The Building Research Advisory Board and the Building Research Institute are units of the Division of Engineering and Industrial Research. Some other well known units in this division include the Advisory Board on Quartermaster Research and Development, the Materials Advisory Board and the Highway Research Board.

Functions of BRAB

Both BRI and BRAB are concerned with the technology of the building industry but their functions and organization are very different. BRAB was established in 1949. It is made up of 30 men who have distinguished themselves as leaders in building research. These men form a board that represents the broad interests of the building industry as a whole, and they meet as often as required to provide advice to government agencies or to industry on problems that need disinterested and objective assessment. Six new members are appointed each year to serve for a term of five years.

Much of the work of BRAB is conducted by special advisory committees. However, the full Board always reviews the work of these committees and in many cases adopts their recommendations for transmittal to the contracting agency. BRAB studies during the past year were commissioned largely by the Federal Housing Administration and the Federal Construction Council. A brief study also was conducted for the Department of Defense on a particular system of building prefabrication.

BRAB has recently completed a series of 12 studies for FHA, each involving a problem controversial in character and troublesome in the administration of FHA's Minimum Property Requirements. The data developed through these BRAB studies have been used in the preparation of the new FHA Minimum Property Standards, which will be issued in the very near future. Of particular interest to mem-

[1] Presented at the Northeast Section Meeting, Oct. 25–26, 1956, in New York, N. Y.

The Author: Harold Horowitz received a B.S. degree in architecture from the Institute of Design, Illinois Institute of Technology in 1950, and a Master in Architecture from Massachusetts Institute of Technology in 1951. He did housing research and architectural work in the East, Midwest and Southwest before joining NAS-NRC.

6 PERCENT AVERAGE MOISTURE CONTENT
9 PERCENT AVERAGE MOISTURE CONTENT
11 PERCENT AVERAGE MOISTURE CONTENT
11 PERCENT AVERAGE MOISTURE CONTENT

Fig. 1.—Illustration from the BRAB report to FHA on Installation of Wood Block Finish Flooring by Adhesive Bonding.

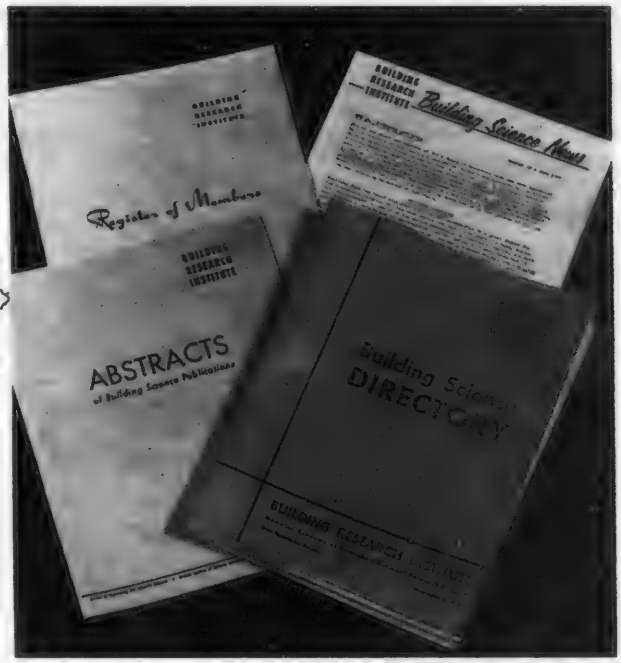


Fig. 2.—The Building Research Institute's membership information services.

bers of the Forest Products Research Society are the studies titled "Installation of Wood Block Flooring by Adhesive Bonding," and "Protection Against Decay and Termites." These and the other ten BRAB studies have now been published and are available in booklet form from the NAS–NRC publications office.

The wood block flooring report emphasized the need for nationally recognized standards for all phases in the manufacture and installation of wood block flooring materials and adhesives. The BRAB committee gave special attention in its conclusions to the importance of moisture control at every stage of manufacture and installation.

BRAB never prepares standards or codes, because to do so would duplicate the functions of existing organizations, and furthermore, would involve the Board in conflicts that might reduce its effectiveness as an impartial body. In the wood block study, the absence of national standards was noted and the committee developed a set of design and installation guides in the form of simple selection charts for adhesives and for appropriate uses of laminated (plywood) block and solid unit blocks. These guides are in no way intended as standards or codes, but simply a method for presenting the best judgment of the committee.

The BRAB committee that conducted the termite and decay study agreed that sound construction practices could do much to eliminate the hazards of termite and decay damage. A major area of discussion was that of wood treatment: its desirability and costs, and particularly the nature of the treatment best suited to lumber uses. The committee recommended treatment of millwork items in accordance with National Woodwork Manufacturers Association standards for use under conditions of alternate wetting and drying, and non-ground contact.

Where ground contact or continuous wetting can be expected, or for structural safety (i. e., sills, porch supports, etc.) pressure treatments should be used. The committee agreed that such treatments constitute a good protection for those pieces of lumber that are so processed, but that it is not economical to treat enough of the lumber in a house to justify it as a termite protective measure for the structure as a whole.

Considerable research is believed to be necessary to determine the amount and type of treatment required for various conditions of exposure to both moisture and insects from the ground upward, and the committee did not make recommendations in this area, aside from suggesting further studies. Attention was given to how wood and cellulose-containing products, subject to decay and termite attack, can be more economically treated and the finished product distributed.

Federal Construction Council Studies

The Federal Construction Council, which also uses BRAB's advisory services, is made up of federal agencies which have important construction programs. Included among them are: The Office of the Chief of Engineers, Dept. of the Army; Bureau of Yards and Docks, Dept. of the Navy; Public Buildings Service, General Services Administration; Veterans Administration; Atomic Energy Commission; and the Bureau of Reclamation. These agencies have been working together informally since June 1953 for the exchange of technical information to improve their policies and practices.

BRAB's advisory services are made available to this group of agencies under a contract between the NAS-NRC and the National Bureau of Standards. The reports made to the Council formerly were confidential and available only to the agencies of the Federal Government. However, a recent policy change permits some of these reports to be distributed to the building industry by BRI. Some of the recent subjects studied by the Council have been: roof decks and built-up roofing; air conditioning in federal buildings; warehouse design; selection of windows; paints for structures; and cooling towers.

Forest products have never been singled out in particular for study by a Federal Construction Council task group, but two of their studies have been related to this field, one on painting practices and one on testing and inspection of materials. The latter study analyzed testing and inspection practices by seven Federal agencies engaged in construction and building research. The purpose was to increase general knowledge of the subject among government technicians and to point the way to improved testing standards and field practices. Three specific building materials, cement, steel and lumber, were considered in detail.

Building Research Institute

The Building Research Institute, on the other hand, is an entirely different type of organization. BRI was established in 1952 as a membership organization, and is rapidly developing into a comprehensive technical society for the building industry. Among its members are architects, engineers, manufacturers, contractors, distributors, building owners, home builders, technical and professional societies, research laboratories, trade and consumer publications, professional consultants and technical experts from colleges, universities and government agencies in this country and abroad. It is one of the few dues-paying groups within NAS–NRC.

BRI activities center around different types of meetings for the purpose of discussing technical developments and problems of importance to the building industry, and delineating areas where further research is necessary. These meetings vary in size. The large public research correlation conferences draw as many as 600 scientists and research-minded persons together to hear technical papers and engage in discussion. The study group meetings and workshops represent smaller activity in a specialized field.

To illustrate, last year BRI held research correlation conferences on windows and glass in the exterior of buildings and on modern masonry (natural stone and clay products). The first was for the purpose of examining the impact of wider use of glass on modern building design and technology; the second was to examine new techniques in masonry construction and spotlight areas for further research. Over 350 people attended each of these conferences. The BRI Plastics Study Group, on the other hand, met twice during the year with an average attendance of 100, to study specific applications of plastics materials in building construction. A workshop was conducted for 60 selected individuals who spent two days discussing specifications and their improvement, 30 devoting their discussion to architectural specifications and the other 30 to electrical-mechanical specifications.

These and other BRI conferences and meetings held during the year produce the material for BRI publications. Proceedings of each meeting are published in book form with illustrations and distributed without charge to all BRI members and to non-members present at the meeting. In addition, BRI publishes and distributes the reports of BRAB studies for the FHA and the Federal Construction Council as these are released for publication.

BRI also maintains an information service for its members which includes a monthly newsletter, a quarterly issue of Abstracts of Building Science Publications, and a comprehensive guide to sources of information on research in the building industry, the Building Science Directory. This directory, which is being augmented each quarter

with additional pages, contains a complete list of associations and societies in the building industry, and separate pages for each organization detailing its activities in research, development or data assembly and analysis.

The only connecting link between BRAB and BRI is their common status as units of the National Academy of Sciences–National Research Council in Washington, D. C., and the fact that William H. Scheick, Executive Director of BRI, is also Executive Director of BRAB. Both organizations, however, are working toward a single objective, the improvement of building technology throughout the entire industry.

Developments Leading Toward a Better Power Chain Saw[1]

JAMES J. CONROY
President, Conroy Publishing Corp., Portland, Ore.

The numerous cycles in chain saw design are traced, with future prospects pointed up. Emphasis is placed on the human aspect—training and educating the operator for most efficient utilization of modern chain saw developments.

Introduction

IF ONE WERE TO DESCRIBE a chain saw, he could very well say, "A chain saw is a sprocket with six or seven teeth, that has on one side a chain running on a long bearing, and on the other side of the sprocket, is a 2-cycle engine that powers the sprocket and the chain."

This may sound strange, but in the 100 years of chain saws, the smallest change has been made in sprockets. The sprocket, therefore, becomes the key or fulcrum point of this discussion. This fulcrum point, the chain saw sprocket, today drives a chain at a speed that places it in contact with the saw chain 900 times per second.

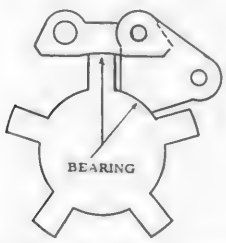


Fig. 1.—A chain saw is basically a sprocket device.

Actually, talk of the future in power chain saw design is merely an echo of the trials and dreams of the good woodsmen in the past who attempted to do in their crude ways the same things that are desired in a chain saw today. Behind each item or part on a chain saw, there is history of a timber harvester desiring such a development. Chain saw design has followed a trend of power unit development, which creates new problems on the other side of the sprocket. Then, as the cutting or "business end" of the saw is developed, there arise new needs for motor or power design.

Engine Design

At the moment, the engine manufacturing phase of the chain saw business has brought designs that show ingenuity, as well as practicality. For example, the compactness of design has now brought power units that will operate at approximately 5 hp., and weigh about 18 pounds. They have brought safety into the use of chain saws from a fire standpoint, as they have kept the motor temperatures safely under the 700-degree fire point. Last year, in one Forestry District in Oregon with over 1,100 saws operating daily, there was only one fire attributed to chain saws in an entire year. In tracing that down, it was found that the timber harvester spilled gas, and did not move the saw before he pulled the starter.

Since today the motors have improved so much that they have caused numerous problems on the cutting end of the chain saw, the balance of this paper will be more concerned with the guide bars and the saw chain, rather than with the magnificent motors that have been designed, to say nothing about the great strides made in carburetion, ignition systems, and various castings that have been integrated into these power units.

Motor manufacturers have placed in the hands of the timber harvester a power unit that will drive a saw chain at the rate of 2,000 feet per minute, or faster if one desires. These power units weigh about 18 pounds. With diaphragm carburetors that permit operation at all angles, moisture-proof, light-weight magnetos that insure ready starting, air-filter placement that allows a tremendous cooling efficiency, which not only eliminates harmful effects to the motor but also discounts fire hazard to an absolute minimum, it appears little else can be done for the motor design that will radically change the design of a chain saw, until the problems created by these motor efficiency designs have been overcome.

Increased Speed

When the motor manufacturer of chain saws designed the direct-drive chain saw, he did so to eliminate the problem of a few years ago,—weight. He also added to the chain saw something else desirable,—speed. In so doing, he caused the chain to revolve around the guide bar or bearing, since that is all it is, at a speed of about 2,000 feet per minute, rather than the former 900 feet per minute.

The chain and guide bar manufacturers had not overcome all the problems of friction, stretch, and educating the user, so with the advent of the faster motors, the problems doubled.

Consequently, the future chain saw will be equipped with guide bar and cutting attachments that will be all one unit. This will eliminate improper mounting of the guide bar on the saw, which causes the chain to excessively wear the bearing surface on the guide bar, as well as the chain and sprocket.

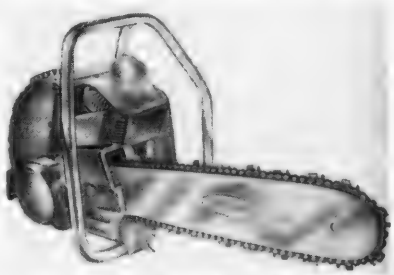


Fig. 2.—A saw chain that is driven at 2,200 feet per minute.

[1] Presented at Session V, Logging, FPRS 11th National Meeting, June 23-28, 1957, in Buffalo, N. Y.

Author: J. J. Conroy is president of the Conroy Publishing Corp., Portland, Ore. and editor of *Chain Saw Age* and *Chain Saw Week*. He also is president of Conroy Publishing, Ltd., Vancouver, B. C., and editor of *Chain Saw Age in Canada*.

The guide bar and the chain will be lubricated in such manner that it will remove the human element that causes an automatic oiler to run dry. These lubrication systems will be of a chemical nature that will be comparable to oil-sealed bearings.

Chain design will be altered to remove the stretch in the rivet holes in the side links that hold the chain. This stretch or elongation of rivet holes is the number one enemy today, as far as saw chain is concerned. Much of the trouble is caused by the improper filing of saw chain. All designs in regard to chain, therefore, must be predicated on the idea that the change in design must make the filing more simple to eliminate human errors in saw chain care. Too many of the saw chain users today actually follow the term "file the chain" rather than "sharpen the chain", and nearly as much saw chain is filed away as is worn away.

Since various timber harvesting jobs are specialized, various other design variations will be developed. While today speed chain saws are available, there will soon be chain saws that will be interchangeable into direct drive or gear driven saws. There also will be, at not too distant date, chain saws that will have gear shifts to permit the changing of speeds at will.

Fig. 3.—Variable-speed chain saw.

Friction Under Abnormal Conditions

The biggest problem, outside of the heat from friction on saw chain, is the loss of efficiency due to instability of the chain on the bearing. As stated before, the newer chains will be designed to eliminate the rocking or dipping motion that creates the stress on the rivet holes as the tooth enters the wood. This stress is tremendous when sawing frozen wood, and it can readily be seen that the ability to change speeds when one encounters frozen timber would be a great asset.

Chain saws are naturally used under abnormal conditions, and this causes

Fig. 4.—Pintail saw tooth designed to eliminate rocking.

excessive chain wear because of friction. These conditions include cutting roots, cutting timber with large quantities of certain chemicals contained, and salvage operations. Carbide-tipped teeth will be available for these jobs. If the cost of these teeth seems out of reason, it is only a matter of education, for the cost of maintaining the standard teeth for use after encountering abnormal conditions is greater than the cost of the carbide teeth.

Motor companies continue to find that various parts of the motor can be placed in more advantageous locations. Recently, for example, a manufacturer built the air filter right into the gas tank, thus removing it from the lower part of the saw where it could become easily clogged.

Handle bars are now being designed with safety built into them, and their locations on the saw are such that the ease of handling is much greater. This is not only a safety factor, but eliminates fatigue in handling for the operator, thus increasing his production.

Probably the greatest development in the design of power chain saws is that which appears in the operator. The operator today is not different from the operator of the old days by accident, but by design on the part of the manufacturer. Each manufacturer has been meeting its obligation of training and informing operators of proper methods of doing their tasks.

Educating the Operator

Chain saw and saw chain manufacturers have done a tremendous job, not only in reducing the cost of harvesting timber, but in aiding the saw user in solving specialized problems. Each new developement in equipment design calls for re-education of the user or operator. In recent years, the changes have arrived with such rapidity that education has been nearly impossible.

Today, however, the operator realizes that these chain saws are tools of his industry that can make him more efficient. Because he has become more receptive to the information made available by his employer and the saw manufacturer, he is well prepared to receive additional education on how to eliminate much waste in his work.

Some examples of this are the acceptance by the operators that the chain must be touched up in the woods, rather than running an entire day, and that the chain must be removed and soaked overnight or for a full day to eliminate fatigue. Both are perfect examples that the future chain saw not only will be better and more efficient in design, but will be operated by chain saw users who actually have been "designed" by the industry.

Discussion

John McAuliffe (McCulloch Motors Corp.): What did you mean when you said much saw chain is filed away, but not sharpened?

Mr. Conroy: I meant that filing is frequently much heavier than it need be, and that many filers get improper horizontal and vertical angles on their files, so that they improve the cutting of the chain teeth little, if at all, yet file away their steel.

Mr. McAuliffe: How about the file guides available from some chain saw and accessory manufacturers?

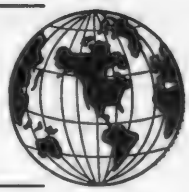
Mr. Conroy: These are a very great help in getting a proper sharpening job. I wish more saw filers would use them.

K. C. Compton (State University of N. Y. College of Forestry): Why didn't you mention the possibility of developing a diesel engine to power a chain saw?

Mr. Conroy: In general, users in the U. S. seem to prefer the gasoline-powered engine. It is easier to start, more responsive, and pound for pound, produces more power. There is a considerable advantage in using a diesel unit, however, in very cold climates. One manufacturer in Sweden is producing such a unit, and about 2,000 of them have been sold in North America. Most of them are being used in Alaska and in Canada.

W. R. Warner (Southern Lumber Co): We have been very much interested in improvement of the power chain saw, particularly the mufflers. There is no question but that the noise made by many modern saws is a safety hazard. At the recent machinery show in connection with the annual meeting of the Southern Pine Association the noise made by the chain-saw demonstrators made conversation almost impossible.

Around the World in Forest Products Research and Development



Commodity Report on Fiberboard

CONDENSATION OF A COMMODITY REPORT based on a paper prepared by the FAO Secretariat for the International Board Consultation held in Geneva, January 21–February 4, 1957. This report appeared in *Unasylva*, Vol. 11, No. 3.

Production

In 1938, world production of fiberboard was under a million tons and mostly confined to North America, Europe and Australia, although Scandinavia was expanding rapidly. The United States accounted for ¾ of world output, producing mainly insulation board. Eighty-five per cent of all fiberboard produced in 1938 was insulation board. At the time, Europe was producing more hardboard than the United States.

At the outbreak of the second world war, insulation board was still the most important fiberboard product. During the war, industry expansion continued in Sweden, Finland and Norway.

By 1948, world production had more than doubled compared with a decade earlier. Europe was producing over a half million tons of fiberboard, of which three fifths was hardboard. The United States was producing more than half a million tons more than a decade earlier; over half of the increase was in hardboard. In 1948, hardboard accounted for nearly 30 per cent of the total fiberboard output against less than 10 per cent in 1938. In Oceania, output nearly doubled, with expansion in Australia and the establishment of the first mill in New Zealand. Several low-capacity plants had been established in the Far East, nearly all in Japan. Still the largest single producer, the United States' share of world production had fallen from 73 per cent to 62 per cent, while that of the three northern European countries had risen from 14 per cent to 19 per cent.

In 1955, fiberboard production topped three million tons, close to the estimated capacity of 3.5 million tons. Table 1 shows that, though still the largest individual producer, the United States accounts for less than half the world output. Secondly, production of hardboard has risen much more quickly than that of insulation board, and accounts for over half of all fiberboard products.

Table 1.—WORLD FIBERBOARD PRODUCTION in 1955 (IN THOUSANDS OF METRIC TONS)

Region	Compressed	Non-compressed	Total
Europe			
Three northern countries	476	176	652
Other	391	163	554
North America			
U. S. A.	485	1,012	1,497
Canada	62	134	196
U. S. S. R.	50	30	80
Oceania	81	15	96
Africa	55	15	70
Asia	25	15	40
Latin America	30	10	40
World	1,655	1,570	3,225

Between 1946 and 1956, world production of fiberboard rose by over 150 per cent. The only setback was in 1952, felt mainly by the three northern European countries. Decentralization of world output is shown in Table 2 as well as percentage shares of the world production.

Table 2. — REGIONAL SHARES OF WORLD FIBERBOARD PRODUCTION, 1938, 1948 AND 1955 (PERCENTAGE OF TOTAL)

Region	1938	1948	1955
North America	77	69	52
of which U. S. A.	(73)	(62)	(46)
Europe	20	28	38
of which three northern countries	(14)	(19)	(20)
All other regions	3	3	10

In 1938, hardboard production was only 15 per cent of all fiberboard production. In 1955, it was 51 per cent of all fiberboard produced. The United States in 1955 accounted for 65 per cent of world output of insulation board, but for only 29 per cent of total hardboard production.

It is expected that by the end of the current decade, world capacity will have risen to 5 million tons, of which probably close to 3 million tons will be hardboard.

World Trade in Fiberboard

The majority of fiberboard produced is consumed domestically, with about one sixth of all produced entering into international trade. In 1955, 11 countries exported over 5,000 tons. In five of these countries (Austria, Belgium, Finland, Norway and Sweden), the fiberboard industry is directed to the export market. North American exports consist of border trade between Canada and the United States. Sweden alone accounts for over half of all world exports, and Finland and Norway together for another 15 per cent.

The bulk of world trade in fiberboard is intra-European, the main flow being from northern Europe to western Europe. Only 12 countries in 1955 imported more than 5,000 tons. The United Kingdom has been the largest importer of fiberboard throughout the decade, accounting in 1955 for more than half of Europe's imports. The Netherlands are second with an import of 56,000 tons in 1955. Comparison figures are as yet not completely reliable, because many importing countries still classify fiberboard under a variety of headings—paperboard, miscellaneous wood products, and so forth.

In the last year or so, small quantities of fiberboard have been sold or offered to Europe from places such as Brazil and New Zealand, while South Africa has readily built up a useful export trade to this market. Seventeen per cent of world production of fiberboard is traded internationally.

Three factors that account for the continued expansion of international trade in fiberboard are: 1) national markets for fiberboard are still small and its uses are experimental. Neither hardboard nor insulation board is a uniform product, so the total consumption of all types of fiberboard is no criterion of the potential market for a particular plant manufacturing specified products. Imports tend to increase until prospective markets have matured to the point at which they will support indigenous production. The establishment of a new mill will seldom satisfy the demand for all board categories, and appearance of domestic supplies may encourage more extensive use and stimulate, rather than replace, imports.

2) In northern Europe, the principal exporting region, there has been a marked tendency towards larger production units, with a consequent fall in average production costs measured in constant prices. Larger scale, lower cost production has reduced the protection afforded by distance and freights. The minimum economic size for a new project in an importing country—the size at which its product can successfully compete with the imported product—has increased.

3) In many importing regions, the imported product may have a quality advantage. This is caused less from the raw material employed than from the acquired skill and experience in controlling the production process. Quality advantage should not, however, be overestimated. In the undeveloped countries demand for a high-grade board with outstanding strength properties is likely to be limited; for most purposes average-quality board will suffice. Resistance to weather, decay and insects are likely to be more important considerations.

Prices

The price of fiberboard over the last two decades has risen much less than that of other forest products, and has been subject to less serious fluctuations. In relation to commodity prices generally, fiberboard has become progressively cheaper. In Sweden, in real terms the price of hardboard has halved while that of insulation board has fallen by one third since 1937.

With the fiberboard industry approaching maturity, opportunities for production economies become fewer and therefore the declining curve of fiberboard prices (in relation to prices generally) must be expected to flatten out in the coming years.

Consumption

Excluding China, the world today consumes nearly 3.5 million tons of fiberboard, which represents an average consumption of about 1.4 kilograms per head. Apparent consumption in 1955 ranged from over 20 kilograms per head in northern Europe to less than one tenth of a kilogram in Asia.

The United States is still the biggest market for fiberboard, followed by the United Kingdom, Canada, Sweden, Western Germany, France and Australia, respectively. The gap in fiberboard usage between Sweden and the other northern countries has closed considerably in recent years. Canada has overtaken the United States, where consumption per head has not shown any great increase. Advances have been registered in Australia and New Zealand, and to a lesser extent in several western European countries.

There is a great potential for increased consumption in east and west Europe, in the United States and in all the less-developed regions. The high consumption rates recorded in northern Europe, Canada and New Zealand may not, however, be realizable in other countries. Climatic conditions and building practices have favored the large-scale use of fiberboard instead of sawnwood and plywood in these countries. The same is true of the United States, but supplies of plywood and lumber in wide and long boards have been more adequate and cheaper than in Europe. In a number of countries, the rising particle board industry has captured markets that might have been won by fiberboard.

Prospects

Fiberboard capacity has risen rapidly since the war, and is still expanding, so that manufacturers in a number of traditional producing centers believe that overinvestment has taken place and that consumption is lagging behind present production potential. Many view with alarm establishment of new capacity in regions outside traditional centers, and feel that if new plants are based on unsound economic lines they may require permanent and excessive protection in order to survive. Some such instances have already occurred.

Fiberboard products are capable of contributing towards raising the living standards of the less-developed regions of the world. In many of these countries, consumption is likely to remain at low levels as long as they have to rely entirely on imports. Expansion of domestic capacity in these countries will considerably stimulate consumption. If importing countries have adequate supplies of suitable raw materials, with the possibility of producing board economically for the markets envisaged, there is a case for new capacity. Current knowledge suggests that a gradual trend towards decentralization of world fiberboard production will make itself felt in the coming years.

In striving to expand existing outlets for its production and to develop new ones, a great variety of types of fiberboard with very diverse properties, characteristics and prices have been developed. On the other hand, individual producers improve the quality of their product to the point where it can compete with those of their competitors and meet specifications where they exist. This gives rise to a trend towards standardized, high-quality production. This trend towards a uniform product is more pronounced in Europe than in the United States. While there is some virtue in having a standard product, which facilitates the establishment of codes and specifications and makes for fair competition between products, there is also a danger that, in many applications, boards will be employed that possess qualities higher than are required. This may be because codes and specifications are insufficiently tolerant, or it may be that cheaper and lower quality boards, though yet adequate, are not being made. This is irrational use, and from the standpoint of the community, represents unnecessary waste.

Discussion at the recent International Board Consultation showed that more exact knowledge about fiberboard's applications will be one of the industry's principal preoccupations in the coming years. To determine the physical properties required in particular applications, to devise appropriate testing methods that will gain general acceptance, and to ensure that officially prescribed codes and specifications are based on actual requirements in use; these are the directions in which research must be intensified if the continued growth of the fiberboard industry is to be assured. Although more is in regard to production techniques and processes, the fiberboard industry is still relatively young in regard to the applications of its manifold products. Up 'til now, demand has been sufficiently strong to ensure outlets in more or less conventional end-uses for all the fiberboard produced.

Table 3.—WORLD CONSUMPTION OF FIBERBOARD IN 1955*

Region	Production:	Imports:	Exports:	Apparent consumption	
	in thousand metric tons			in kgs/head	
Europe	1,206	334	453	1,087	2.7
3 northern countries	652	---	349	303	20.5
Others	554	334	104	784	2.0
North America	1,693	42	67	1,668	9.3
U. S. A.	1,497	21	24	1,494	9.2
Canada	196	21	43	174	11.4
U. S. S. R.	80	---	---	80	0.37
Oceania	96	7	2	101	7.0
Africa	70	18	20	68	0.32
Union of S. Africa	70	1	20	51	3.8
Asia (excl. China)	40	44	5	79	0.09
Latin America	40	4	2	42	0.24
WORLD	3,225	449	549	3,125	1.5

*The figures in this table slightly understate consumption, especially in the less-developed regions. These also do not take into consideration changes in stocks at mills or in the hands of distributors and consumers.

Consumption includes utilization in further manufacture—part of which may be destined for export. Since the three northern countries export prefabricated houses containing fibreboards, the per capita consumption figures quoted here overstate final consumption by the nationals of those countries.

Review of FPRS Contributed Paper

Surface Waviness of Lumber-And Particle-Core Panels [1]

J. E. Marian and O. Suchsland, University of California Forest Products Laboratory, Richmond California

Waviness of high-gloss polished panels is a common trouble in the manufacture of furniture parts such as table tops, doors, and so forth. An investigation has been carried out to find out the main causes of waviness in order to devise practical means to minimize or avoid this trouble. A simple practical method has been developed by which the future appearance of waviness in any flat constructional parts may be measured and predicted. The influence of the main relevant production and construction factors have been studied with this method.

A number of methods have been used for observation or recording of waviness. In this case, a very high degree of precision was required. Practical experience teaches that wave height (depth) is very small, usually around 0.1 to 0.001 mm. To measure with this accuracy, the device shown in Fig. 1 has been developed.

The device is a tracer instrument that measures deviations of a lacquered surface from a plane of reference. The apparatus consists of an accurately ground glass plate that carries four steel pins. One of these is micrometrically adjustable, and permits the measurment of any warping in core boards placed on three pins. The waviness of core boards is determined by means of a movable traveling micrometer through measurement of the varying distance between the base plate and the points on the lacquered surface of the core boards. A gridiron pattern of coordinates is drawn on the lacquered surfaces.

The cores of the boards were conditioned after preparation at 30 per cent r. h. at 25° C., then crossbanded and veneered, reconditioned for seven days, and sanded. The high-gloss surfaces were prepared with nitrocellulose lacquer according to a conventional procedure. The surface profile determinations were made immediately, followed by reconditioning for 30 days at 60 per cent r. h. at 20° C. The surface profiles were then determined again.

[1] This is a condensation of a paper published in Paper and Timber, No. 6–7, 1956, while the authors were associated with the Swedish Forest Products Research Laboratory, Wood Technology Department, Stockholm.

Fig. 1.—Device for the simultaneous registration of warping and waviness (surface profile measurements).

The values were plotted as ordinates, and the curves of the profile were drawn. Intervals of 30 mm were marked on the observational curve, and were drawn as a compensated curve. The area between the observational and compensated curves was determined graphically (Fig. 2). The sum of these areas (in sq. mm.) is a measure of unevenness. If boards are tested before and after humidity changes, these values of unevenness can be used as ratings of surface stability. Fig. 3 shows surface stability of boards made from 1) non-glued cores, 2) glued blocks, and 3) particle board.

Fig. 2.—Planimetric construction of the mean curve of compensation in surface profile measurements.

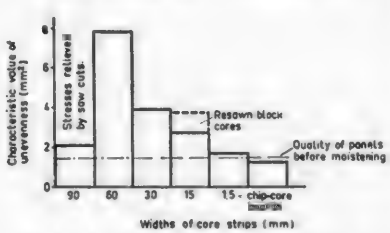


Fig. 3.—Surface stability of non glued core stock as a function of core-strip widths.

Surface instability of core board panels can be traced to two main causes:

1. Swelling or shrinking (deformation) of the anisotropic core material, which consists of strips with varying positions of the year rings, under changes of humidity, temperature, or both.

2. "Sunken joints", that is, differential swelling of the adhesive-impregnated joint and adhesive-free wood, under changes of humidity, temperature, or both.

These dimensional variations appear after a certain lapse of time necessary to develop stresses through changes of humidity or temperature. Dimensional variations can be minimized or eliminated by the following main types of procedures:

(a) Orientation of the strips in the core with respect to year rings,
(b) Sawing from blocks,
(c) Non-gluing of the core strips,
(d) Grooving ("tenderizing"),
(e) Decreasing core-strip widths,
(f) Using cores of reaggregated wood.

Observability of waviness depends not only on the depth or height of the irregularities but also on the ratio of wave amplitude to wave length It means that short waves are more easily observed than are long waves of the same height.

The important feature in core panels is not surface quality but surface stability. Panels with perfect appearances at shop inspection might develop waviness as a consequence of moisture and temperature changes. Thus the method developed permits the prediction of surface quality in the future and, as far as climatic conditions can be simulated, a testing under accelerated laboratory conditions.

The method is a simple procedure by which the appearance of waviness in the future may be minimized through the proper choice of production and construction factors.

Abstracts From Current World Literature

Stabilization

Johansson, Eric. Decreasing the swelling of wood-fiberboards. *Holz Roh- u. Werkstoff* 15, no. 1: 9–11 (Jan., 1957). [In German; English summary]

After reviewing the causes of swelling of fiberboard in water, the author discusses various dimensional stabilization treatments. Impregnation of the boards with 8–12% of various oils, notably linseed oil, followed by thermal treatment reduces the water absorption to 11.5–14.3%. Approximately equally effective and probably more economical is the addition of about 1% of various chemicals to the chips before or during defiberization. The resulting hydrophobing effect is presumably due to a crosslinking reaction similar to vulcanization. Spruce and pine fiberboards so treated showed a water absorption of 14.6% in 24 hr. after a thermal hardening treatment. For beechwood, the absorption was higher, 28.3%. A more drastic reduction of swelling was obtained by sizing fiberboards with 0.5% tall oil ester wax. When 3% tall oil wax was used, the sealing effect obtained (6.6% water absorption in 24 hr.) obviated the necessity of a thermal aftertreatment and retained much of its efficiency after 180 days of weathering. However, heat treatment is still advisable where a high bending strength is mandatory. [Bul. Pap. Chem. V. 27, No. 8]

Fiberboard

Segring, S. Bertil. The pressing of hard fiberboards. *Holz Roh- u. Werkstoff* 15, no. 1: 1–9 (Jan., 1957). [In German; English summary]

The theory and practice of hard fiberboard manufacture are outlined. The press is the most important and most expensive machine in a fiberboard plant. Developments to improve its capacity are described, including various press constructions, heating plates, and hydraulic systems. Charging or loading devices are an essential part of the press and should be adjusted precisely to obtain the maximum capacity. Press dimensions, size, and capacity depend on the field of application and on market conditions. Special care and attention must be given to the shielding of the machine to obtain optimum heat transfer. Heat requirements and consumption are investigated. Waste water and steam can be put to several thermal uses. [Bul. Pap. Chem. V. 27, No. 8]

Barking

Fobes, E. W. Developments in debarking. *Tappi* 40, no. 3: 178–80A (March, 1957).

There are 56,000 sawmills and only 266 pulp mills in the United States. Barkers developed and used by the lumber industry, including machines for sawlogs and slabs, are often equally suitable for pulpwood debarking and sometimes superior to pulplog barkers. The productive capacity of sawlog barkers is specified in lineal ft./min.; conversion tables and charts relating lineal ft. to cords are given. Most new round-wood barkers operate on one of two principles—either chain flails beat off the bark or the bark is sheared off by pressure applied to the tool. Three types of slab and edging debarkers are in use: one employs the cambium shearing principle, another uses chain flails, and the third uses hammers to remove the bark. Three round-log barkers of the chain-flail type can process 70 lineal ft./min. at 60% of the machine cost of a conventional barking drum. [Bul. Pap. Chem. V. 27, No. 9]

Anon. The Bark-Lasse spiral milling cutter debarker. *Papier, carton et cellulose* 5, no. 6: 116–17; summary: 70 (Jan.-Feb., 1957). [In French and Spanish; English summary]

The Swedish Bark-Lasse portable barker, mounted on two wheels, can bark logs of small diameter (1.5–9.8 inches) at the rate of 882–1400 cu. ft./8 hr. with two operators. A guide-support passes the logs under a spiral milling cutter rotating at 6000 r.p.m. which is pressed against the bark by an arm while two toothed wheels rotate the log about its axis and move it along at a speed adjustable between 0 and 26 f.p.m. The speed and pressure of the milling head can also be adjusted according to the wood species. It requires no sharpening for periods up to 6 months. Power is supplied by an 11-kw. electric motor, a 15-h.p. gasoline engine, or more usually by an agricultural tractor. Two types of milling cutter are available, one for freshly cut and one for dry or frozen wood. The standard model is designed for logs 6–16 ft. long, but special guides make it possible to handle logs shorter than 6 ft. Trials on various hardwood logs gave satisfactory, although mostly partial, removal of bark without substantial wood losses. [Bul. Pap. Chem. V. 27, No. 8]

Lumber

Sizes of timber B. Alwyn Jay (Timber Development Association) *Wood*, Vol. 21 No. 7, July 1956, pp. 276–8, illus.

Because timber comes from trees of so many sizes and shapes, there is inevitably a great variation in the sizes of sawn timber available to the consumer, and a few technical tips can avoid wasted time and money.

However suitable a timber for a particular purpose, the available sizes should always be considered first and care taken to state whether sizes are nominal or actual. Very wide widths are seldom obtainable or economical in square edged timber. With a few exceptions, such as obeche and African mahogany, the proportion of boards with no taper in the length is very small and wide boards are comparatively costly. The approximate maximum widths obtainable from normal parcels of imported square edged timbers are as follows:

- African mahogany, sapele—20–24in.
- Tropical hardwoods such as obeche, iroko, agba and seraya—16–20in.
- European oak and beech—9–10in.
- Japanese oak—10–11in (12–20in sometimes available at considerably increased cost).
- Most West Canadian softwoods; especially Douglas fir, western hemlock and western red cedar—12–16in. Over 12in occurs only in small quantities in high quality. (Western red cedar seldom more than 12in).
- Parana pine—12in. (Some up to 16in).
- Most East Canadian softwoods except yellow pine—11in. (Occasionally some 12in).

It is important to remember that prices rise very sharply as widths increase beyond certain limits and that 90% of the timber trade deals mainly in lengths of 6–16ft and widths of between 6 and 10in. With normal imported hardwoods which arrive in this country in random widths and lengths, a certain amount of waste is inevitable but some thought about the range of imported sizes before ordering and the skill of a good supplier will help to reduce this waste. [F.D.C. Tech. Bul. V–6, No. 35]

Drying

Görling, P. Research results and trends in drying technology. *Chem.-Ing.-Tech.* 29, no. 3: 170–6 (March, 1957). [In German]

The laws governing partial processes of drying and their interaction have been largely clarified by previous research. With present knowledge it becomes possible to investigate the drying behavior of various hygroscopic and nonhygroscopic materials and to define specific drying properties in a way which permits the prediction of the most important characteristic points in the course of drying. Various types of moisture movement (capillary movement, liquid diffusion, surface diffusion, vapor diffusion, and vapor convection) are defined, and the practical drying of various materials including causes of damage, is discussed. For constant drying conditions, the course of drying can be predetermined for any material from a knowledge of five characteristics—sorption isotherms, inversion point at a given temperature, effective pore width or pore distribution, diffusion-resistance factor, and heat conductivity. [Bul. Pap. Chem. V. 27, N. 9]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Eleventh National Meeting Attended by 672

(continued from page 37-A)

Nicholson Manufacturing Co., Auburn, Wash.
Pacific Lumber Co., Scotia, Calif.
Pannill Veneer Co., Ltd., Kitchener, Ont.
Perkins Glue Co., Lansdale, Pa.
Preston Woodworking Machinery Co., Ltd., Preston, Ont.
Protection Products Manufacturing Co., Kalamazoo, Mich.
Reichhold Chemicals, Inc., White Plains, N. Y.
Simonds Saw and Steel Co., Fitchburgh, Mass.
Soderhamn Machine Manufacturing Co., Talladega, Ala.
Southern Screw Co., Statesville, N. C.
Standard Dry Kiln Co., Indianapolis, Ind.
Synvar Corp., Wilmington, Del.
Timber Engineering Co., Washington, D. C.
U. S. Plywood Corp., New York
Washington Iron Works, Seattle, Wash.
Weyerhaeuser Timber Co., Tacoma, Wash.
Wilco Machine Works, Inc., Memphis, Tenn.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.
S. A. Woods Machine Co., Boston, Mass.
Yates-American Machine Co., Beloit, Wis.

Ladies Program

This year's ladies' and children's program was one of the most outstanding planned for a National Meeting. A get-acquainted Kaffee Klatch attended by the ladies was held in the Buffalo Room on Monday morning. The Official Ladies' Tea, with Mrs. Ralph H. Bescher as hostess, was held on Tuesday afternoon in the Empire State Room.

Particularly enjoyable for the children was a picnic box supper and tour of the zoo, supervised by experienced personnel. The children were taken to the zoo by bus at 5:00 P. M. and returned at nine in the evening.

Wednesday afternoon, both ladies and children enjoyed a tour of the Canadian side of the Niagara Falls. An opportunity to shop was provided, and tea was had at the Sheraton Brock Hotel. From the tour, ladies and children joined the men at the Paul Bunyan Smorgasbord at Brock Monument Park.

Final windup of the ladies' program was a tour of the General Mills plant led by Betty Crocker. The tour was held at the largest flour plant of General Mills. The ladies joined in many of the social events with the men, such as the official luncheon and the official party and banquet.

400 Attend Plant Tours

Plant Tours on Wednesday afternoon were heavily attended, with more than 400 persons participating. The plants visited were the Carborundum Co., featuring a tour of the Abrasives Division; the Upson Co., covering a variety of products including laminated panels, Upson Board, and various kinds of paper; the Kittinger Co., the exclusive appointee as maker of Williamsburg Restoration Furniture; and the R. Wurlitzer Co., featuring the largest plant in the U. S. devoted to the manufacture of musical instruments.

CANADIAN WOOD pulp used for liner on Upson Board shown during the Upson Plant tour.

AT UPSON, l. to r.: George H. Schmidt, FPRS national office; Dr. Takamaro Maku, Kyoto University, Japan; Dr. Walter P. Ericks, vice president and director of research at Upson; new FPRS President F. H. Kaufert, and James J. Upson, president, Upson Co.

BEATER ROOM of the Upson Co. plant where raw stock is processed for use in the manufacture of Upson Board viewed by FPRS members.

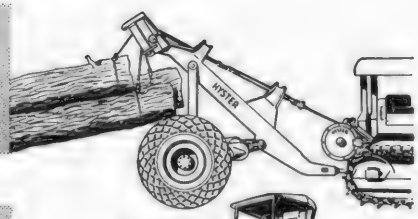
DRY KILNS at the Kittinger Co.

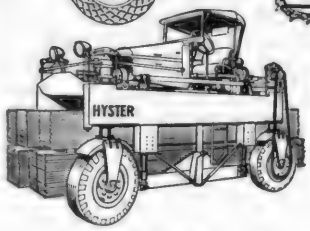
FAMED reproductions of Williamsburg Colonial furniture are viewed at the Kittinger Co. plant.

in the WOODS

in the MILL

in the YARD





...wherever lumber is being produced or handled you'll find this world-famous HYSTER® symbol on the equipment that does the heavy work.

IN THE WOODS...HYSTER Winches are doubling the pulling power of Caterpillar-built tractors...HYSTER Arches and the Sulky® are making selective logging possible and profitable...HYSTER Yarders and Tractor Donkeys® are running the high-lead show.

IN THE MILL...HYSTER Straddle Trucks® and heavy duty Lift Trucks are moving and stacking lumber...loading cars and trucks.

IN THE YARD...HYSTER Lift Trucks, large, medium and small, are moving lumber in and out of yard and shed storage, loading and unloading trucks and cars and even making short-haul deliveries.

For over a quarter of a century Hyster has pioneered new methods and equipment to serve the forest industries. Hyster manufactures a complete line of tractor attachments for all size tractors, and Industrial Trucks from 1,000 to 30,000 lb. capacity.

Today there are over 700 dealers throughout the world who sell and service Hyster Tractor Equipment and Industrial Trucks.

HYSTER

HYSTER COMPANY FACTORIES
DANVILLE, ILLINOIS • PEORIA, ILLINOIS • PORTLAND, OREGON

GLASGOW SCOTLAND • NIJMEGEN, THE NETHERLANDS • SAO PAULO, BRAZIL • SYDNEY, AUSTRALIA *
* UNDER LICENSE

OUTGOING President Ralph H. Bescher presents gavel of office to Dr. F. H. Kaufert.

FIRST of two shirt sleeve sessions held by the National Executive Board at the Buffalo meeting.

Door Prizes

Seventeen door prizes were a feature of the Official FPRS Banquet and Party, all donated by local furniture companies and other manufacturing concerns. A partial list of these prizes and winners is shown below.

Other prizes included five carving sets donated by the Carborundum Corp., a portable radio donated by the Rudolph Wurlitzer Co., a set of dishes donated by American Cyanamid Corp., and a belt axe donated by the True Temper Corp.

Employment Committee

Operated under the direction of Dr. Newell A. Norton, Penn. State University, the FPRS Employment Service was available for private interviews with employers seeking personnel during the meeting. The service was open for one and a half to two hours daily during the meeting. Eleven applications for positions and four from companies were processed. A number of contacts were made for each application. At times, there were as many as eight persons seeking counsel at one time.

Alumni Reunions

Traditional alumni get-togethers were held by five different schools during the Annual Meeting. Yale University held a breakfast attended by 16 persons Thursday morning. Twelve Penn. State alumni celebrated with a breakfast on Thursday morning. FPRS President Kaufert was honored at the University of Minnesota breakfast on Wednesday morning, attended by 19 persons. Forty-two persons attended the N. Y. State College of Forestry breakfast on Wednesday morning. University of Michigan alumni also celebrated with a luncheon held during the meeting.

A FEW of the many beautiful door prizes donated by furniture and other supplying industries.

Open-House Tours

Twenty-five wood industry plants and laboratories within a 200-mile radius of Buffalo cooperated in the program of open-house tours after the meeting. The tours were held on Friday, June 28, for the benefit of the Annual Meeting registrants.

Approximately 100 persons participating in the open-house tours visited the facilities of the new $3.75 million Hugh P. Baker Laboratory at the State University of New York College of Forestry, at Syracuse. The laboratory was dedicated this past May.

Other Features

Division business meetings were held on the first day of the meeting. The agenda included a report of the year's activities, a program of new activities, discussion of new developments, and an analysis of individual problems. (See complete report elsewhere in this issue).

The traditional Past Presidents' Dinner was again held this year. Other events included special luncheons for the Section Officers' Advisory Council and the Division Officers. (See contents for page account).

Door Prize	*Donor*	*Recipient*
2 mahogany chairs	Jamestown Lounge Co.	Mr. Duane L. Kenaga
1 pull-up table	Hekman Furniture Co.	Mrs. Florence Gurvitch
1 Barcalounger	Barcalo Mfg. Co.	Mr. O. B. Derr
1 ard table	Norquist Products, Inc.	Mr. William S. Sloatman, 'Jr.
1 Windsor armchair	Lewisburg Chair Co.	Mr. S. S. Sakornbut
1 Windsor armchair	Sikes Co.	Mrs. Fred Meyer
1 ull-up table	Union National Furniture Co.	Mrs. Sigurd Johnson
2 ide chairs	Fancher Furniture Co.	Mr. Arthur Iffland
1 ip-top table	Kittinger Co.	Mr. George Skinner

Mats of wood particle board going into the multi-platen hot plate press to produce two flake type particle boards at the TECO pilot plant. The press produces boards 3' x 6' and has ample capacity to provide a wide range of density for standard particle boards, insulation boards or even floor tile.

NEW PARTICLE BOARD PILOT PLANT

- DEVELOPMENT
- TESTING
- EVALUATION

The Timber Engineering Company's new wood particle board pilot plant is fully equipped to develop any kind of platen type wood particle boards, with companion facilities and personnel for testing both platen and extrusion boards, raw materials, production processes, end uses, and markets.

The TECO Pilot Plant is unique because of its large size which allows the production of particle boards of ample dimensions for normal end uses. Actual large scale production facilities can be accurately forecast by completely conveyorized operations simulating a mass-producing commercial plant.

Here are the new services

For MANUFACTURERS of PARTICLE BOARD

We can test present boards to determine their exact properties and quality; conformance to specifications and standards; opportunities for improvements; and their most suitable end uses.

For THOSE PLANNING PARTICLE BOARD PRODUCTION

We can evaluate the suitability of raw materials; counsel on selection of equipment; develop formulae for the best boards obtainable from available raw materials, and for end uses; evaluate markets for specific boards; and develop boards for specific markets.

For SUPPLIERS to PARTICLE BOARD MANUFACTURERS

We can assist manufacturers of adhesives and preservatives, moisture resistants, fire repellants, colors and other additives, in developing, improving, or adapting their products for use in particle board production.

Firms, wishing to supply particle board producers with basic raw materials from their mills, plants, or timber tracts, will find our services valuable in determining the type of board for which the residues are most suitable, and methods for separating and handling them.

For USERS OF PARTICLE BOARD

We can help determine the type of board required, and evaluate properties of boards for particular uses.

We invite inquiries from the lumber and wood-using industries, and from other industrial firms interested in particle board production or consumption.

TECO TIMBER ENGINEERING COMPANY

1319 18TH STREET, N.W., WASHINGTON 6, D.C.

RESEARCH AFFILIATE OF NATIONAL LUMBER MANUFACTURERS ASSOCIATION

PAST PRESIDENTS and their wives attend traditional dinner.

OFFICIAL Ladies Tea with Mrs. Ralph H. Bescher as hostess.

DR. ERIC ANDERSON, Chairman of the Northeast Section Student Award Committee makes presentation as Dr. L. R. Thiesmeyer looks on.

NORTHEAST Section officers, who with the Eastern Canadian Section served as hosts at the 11th National Meeting.

UNIVERSITY OF MICHIGAN alumni luncheon.

N. Y. STATE College of Forestry alumni breakfast.

A "UMBRELLA" demonstrator delights guests with unique collection.

REUNION BREAKFAST—held by Yale School of Forestry alumni.

MURCO 48" — 6 knife Wastewood Chipper with 7' x15" spout installed by WEYERHAEUSER TIMBER CO.

MURCO — 12 knife — 64" Wastewood Chipper installed by Hallack & Howard Lumber Co. Winchester, Idaho.

You, too, can produce quality marketable chips with.... MURCO WASTEWOOD CHIPPERS

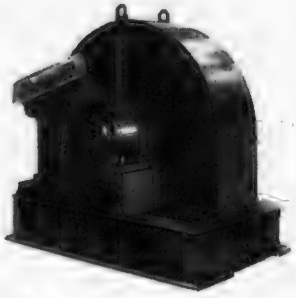
Produce quality specification-size chips from slabs, edgings, planer trimmings, round wood, veneer cores with MURCO Wastewood Chippers, backed by over thirty years' experience . . . the most versatile, flexible chipper design now available to chip producers. Used by lumber companies and timber operators throughout the country.

Their preference for MURCO Chippers comes from the MURCO outstanding performance, producing more and better chips at less cost with less sawdust and slivers, free from repairs while at the same time having production records of one hundred cords or over per hour. It will pay you to investigate what MURCO Chippers can do for you.

MURCO Small Log Chipper made in sizes 36", 42", 48", 54", and 60" diameter discs. All are ruggedly built for production.

MURCO High Speed Multi-Knife Wastewood Chipper . . . made in three sizes, 56", 64", and 72" diameter discs. In addition to the above chippers, the MURCO 75" diameter four-knife mechanical feed wastewood chipper is now serving a number of lumber companies.

MURCO SMALL LOG CHIPPERS



MURCO MULTI-KNIFE WASTEWOOD CHIPPERS

A complete and detailed story o pulpwood and wastewood chippe is contained in the new MURC Chipper booklet . . . comple specifications of each model. W will gladly send you a copy o request. Write for it today!

D. J. MURRAY MANUFACTURING CO.

Manufacturers Since 1883 • WAUSAU, WISCONSIN

56 Firms Show Products at FPRS Suppliers Exhibit

(continued from page 39-A)

Exhibit Chairman R. C. Deckert and H. L. Bennett.

Masonite Corp.

Perkins Glue Co.

National Casein Co.

Fjellman American, Inc.

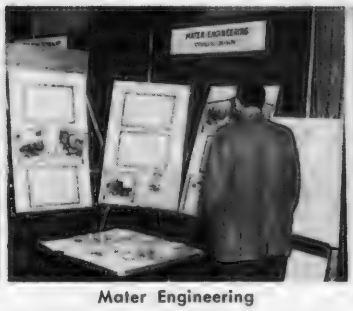
Standard Dry Kiln Co.

Moore Dry Kiln Co.

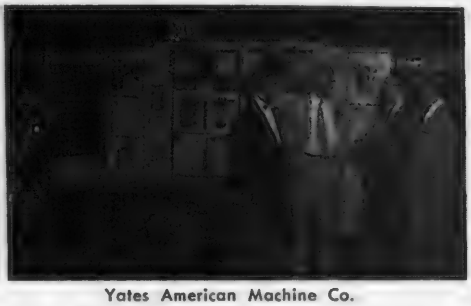
Kennametal, Inc.

Reichhold Chemicals, Inc.

National Adhesives



Mater Engineering



Yates American Machine Co.

N. Y. State College of Forestry.

The Wood Worker and Veneers & Plywood.

Yale University School of Forestry.

AUTOMATIC EQUIPMENT

FOR

More Profit

High speed upholstery tacking
Photo courtesy Kroehler Mfg. Co.

Drive Tacks, Nails, Screws AUTOMATICALLY with

POWASERT

TACKS — from ¼" to ¾" — up to 300 a minute
NAILS — from 2 to 16 penny — up to 150 per minute
SCREWS — from ½" to 1¾" — up to 60 per minute
Work in oak, maple, mahogany, birch, pine, fir, etc.

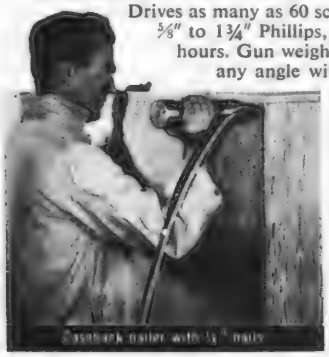
Phenomenal savings in production time are now possible with POWASERT. These lightweight, versatile tools feed and drive automatically, require no special skills to operate, leave one hand free for assembly, holding or positioning. Write us today about your applications.

POWASERT TACKER. Drives up to ¾" at 300 per minute. Made in Models A and B. **Model A** for upholstering and other tacking operations — handles 9 tack sizes from ¼" to ¾" with a simple change of one fitting. Now available. **Model B** for light nailing — casebacks, toys, etc. Will handle ¾" nails with head sizes to 3/16" and shank size to .072. Scheduled for Fall delivery.

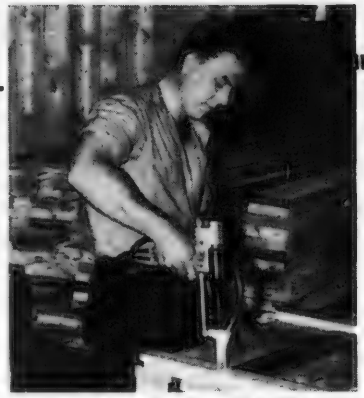
POWASERT NAILER A. Drives up to 5d . . . at speeds up to 150 per minute. Feeds, drives nails vertically or horizontally at rates as high as 150 nails per minute automatically. To be made in two models for driving from 1" to 1¾" with head sizes from 7/32" to 5/16" or ¾" to 1¼" with head sizes from 11/64" to 13/64". Shank sizes 12 to 15 gauge. Will drive all types — common, box, bright, acid-etched, annular or helical grooved. Weighs only 5 lb. and can be operated with one hand. Excellent in tight, close areas. Drives nails with one tap. Scheduled for delivery in Fall.

POWASERT NAILER B. Drives up to 16d at 50 per minute. Light, small, easily handled — works more than twice as fast as a hammer. Drives at any angle, straight, or clinched at speeds up to 50 nails per minute. Nails can be "tacked", driven flush, or countersunk. Guns made in three models, weighing 5, 6 and 7 lb.; lengths 11", 14½" and 18½", 2d to 5d, 5d-10d and 6d to 16d. All three models can be used with same automatic feeder. Now available.

POWASERT SCREWDRIVER. Drives up to 1¾" screws at 60 per minute automatically. Drives as many as 60 screws per minute in any kind of wood. Handles from 5/8" to 1¾" Phillips, Frearson or slotted screws — sufficient for several hours. Gun weighs only four pounds and operator can drive screws at any angle with one hand. Shipments now being made. Applications include furniture, millwork, cabinets, etc.

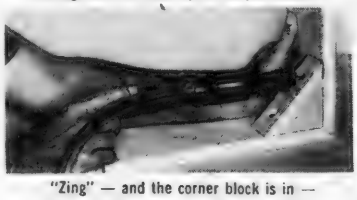


Casebank nailer with ¾" nails



Nailer B feeds and drives up to 16d

Crating with box nails up to 150 per minute



"Zing" — and the corner block is in — ½" to 1¼" screws up to 60 per minute

United

SHOE MACHINERY CORPORATION
Industrial Sales Division
140 Federal St., Boston, Mass.

Close Cooperation Stressed by FPRS 14 Divisions

Division Officers Recommend Plans at Special Luncheon

The Society's Division representatives met on two occasions during the 11th Annual Meeting in Buffalo. They met as a group on Tuesday, June 24, and presented their formal recommendations at a luncheon meeting, Thursday, June 27, held in the Boston Room. Roy M. Carter, a Past-President of the Society, and one of the initiators of the Division program, served as chairman.

Strengthened liaison between the Divisions and the National Executive Board and between the Divisions and the Sections was suggested. The following recommendations were made.

1. The Executive Board and Madison Office should develop a guide to Division organization, scope, and operation for use by Division Officers. Suggestions for inclusion in such a guide should be circulated to Division Officers prior to final publication. It was suggested that a Past-Chairman serve on the Division Steering Committee in connection with the Division Operational Guide.

2. The Executive Board and Madison Office should determine the Division interest of FPRS members by mean of a mail questionnaire at the earliest date. The questionnaire is to provide space for checking off the first three choices of Division affiliation. It was suggested that a committee consisting of M. H. Mater, H. O. Fleischer, and A. S. Gregory work with the Executive Board Coordinator to draft the questionnaire. The poll is not to be used to terminate existing Divisions.

3. Close coordination between the Divisions and Sections should be established in regard to developing Section technical programs.

4. The Division Coordinator (Vice-President) should send to the Divisions any information that might be of interest on the activities of other Divisions. A Division column in the JOURNAL was discussed as a future possibility.

5. The Divisions would like to have business meetings held during the middle of the Annual Meeting rather than at the beginning or the end. Divisions that overlap others, such as Industry–Education and Merchandising, could meet at a different time.

6. Half-day trips should not be scheduled during the technical sessions.

7. Discussion was held on the desirability of distributing preprints of papers presented at technical sessions. The suggestion was made that each division handle the situation directly with authors, asking them to supply an ample number of copies for session distribution so that presentation can be improved by permitting review of the paper before the session, and more time for discussion.

8. Division Chairmen should be notified as soon as plans are launched for the 12th Annual Meeting, so that preparations for technical sessions can proceed.

9. The name of the Marketing Division should be changed to Merchandising Division.

10. All Divisions except Merchandising and Packaging requested a technical session at the next National Meeting. Merchandising requested a paper at the General Session.

DIVISION OFFICERS LUNCHEON

Those in attendance at the meeting were: A. H. Bishop, Wood Preservation; F. H. Thomas, Wood Finishing; Ira Hatfield, Wood Preservation; M. H. Mater, Lumber Manufacturing; A. R. Tegge, Packaging; I. A. Pearl, Chemical Utilization; A. S. Gregory, Chemical Utilization; Fred Simmons, Logging; Alex Panshin, Industry–Education; James Bethel, Industry–Education; R. F. Blomquist, Glues and Gluing; John D. Ritchie, Veneers and Plywood; H. O. Fleischer, Veneers and Plywood; J. R. Roberts, Wood Composition Board; G. E. Olson, Merchandising; S. B. Preston, Drying; N. A. Norton, Employment; A. A. Marra, Glues and Gluing; Charles Latimer, Quality Control; Paul H. Graham, Publicity; David E. Herrick, Lumber Manufacturing; Wm. K. Stamets, Jr., Lumber Manufacturing; G. G. Marra, Wood Composition Board; Roy M. Carter, Past President.

Minutes of 1957 Division Meetings

CHEMICAL UTILIZATION—Chairman, E. G. Locke, U. S. Forest Products Laboratory, Madison, Wisconsin.

I. Wood Section Created in CHEMICAL ABSTRACTS.

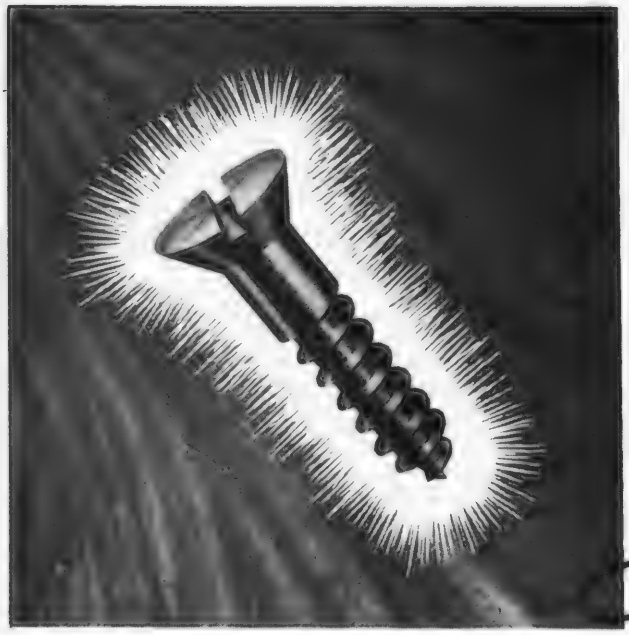
S. A. Woodruff reported on efforts to promote a wod section in CHEMICAL ABSTRACTS. The Cellulose section was changed to "Cellulose, Paper, Lignin and Other Wood Products", effective January 1, 1957. Dr. Locke expressed appreciation to S. A. Woodruff and A. S. Gregory in discharging their work on this committee.

II. Program for the Buffalo Meeting.

Dr. A. S. Gregory reported that he had approached some 35 companies for papers, and had encountered a generally negative attitude toward giving information in technical papers. He felt, however, that the ice was broken, and that a better response would be forthcoming in the future. Expectation of a good program was expressed but disappointment was felt on the timing for the session (Thursday). It was also felt that the Monday morning Division business meeting was too early in the National Meeting schedule, interfering with attendance by people who did not wish to travel on the weekend.

III. Old Business.

The membership expressed the opinion that the annual review was a valuable contribution and should be



Quality

that protects your company's name...

There is no substitute for quality whether you are interested in the components, the workmanship or the end product you manufacture.

One of the basic components of almost every industry is fasteners. Successful operations that cash in on every opportunity for faster assembly utilizing maximum worker output with minimum loss of materials — find that quality fasteners such as Southern Screws form a dependable foundation for profitable production.

Although Southern has earned for itself an enviable reputation for fast service, and its stock of over One Billion fasteners — Quality is the benchmark of Southern products . . . Constant quality that has become synonymous only with U.S.A.-made fasteners produced by U.S.A. workers.

Wood Screws
Machine Screws
A, B, C & F Tapping Screws
Wood & Type U Drive Screws
Dowel Screws
Stove Bolts
Carriage Bolts
Hanger Bolts

If yours is a quality product, protect your company's name with Southern fasteners. Southern makes every screw it sells! Wide variety of head styles, materials and finishes . . .

Write, on Company letterhead, for Stock List, free samples and Warehouse Stock Guide, Box 1360-FPJ, Statesville, N. C.

Warehouses:

NEW YORK — DALLAS
CHICAGO — LOS ANGELES

continued. Discussion developed on the breakdown of fields which should be covered and the following suggestions were made: charcoal (or pyrolysis); lignin; bark; extraneous materials (or extractives); chemical derivatives; cellulose; marketing, material handling, transportation, economics; raw material supplies; fiber products (to include pulp and paper, but not boards, which are covered by Composition Board Division); microbiological digestion; soil amendments; and modified woods.

V. Abstracting Service Suggested.

Preparation of bibliographies on subjects of interest to the Division was discussed. S. A. Woodruff reported that he was unable to obtain a release from his sponsor to submit a bibliography on bark. Those who had assumed responsibility for other bibliographies were not present to report. C. S. Dosker felt that preparation of bibliographies was a definite function of the Society and of the Divisions. He pointed out the problem of getting volunteers for this work because of the amount of time needed to prepare abstracts which go beyond mere title listings, and suggested that the work be contracted out, with funds to be raised by obtaining industrial sponsors. Dr. Locke indicated the Publications Committee's interest in starting an abstracting service. It was suggested that the Division officers further investigate this possibility.

V. Plans for the 1958 National Meeting.

The Division agreed to sponsor a technical session, with a similar format to this year's session. A suggestion was made that a full day be alloted, with general papers scheduled for the morning, and a symposium in the afternoon. Suggestions for the symposium were charcoal, bark utilization, and furfural. Interest of the ACS Cellulose Division in presenting fundamental papers on the chemistry of bark was mentioned. It was suggested that a planned format of the Division business meeting be made in order to attract more people.

Discussion was held on the desirability of arranging a joint symposium with the Logging Division on raw materials handling, costs, and availability. The general consensus was that such a session should not replace the technical session suggested previously, but might be a worthwhile supplement. The chairman was asked to explore this possibility with the chairman of the Logging Division.

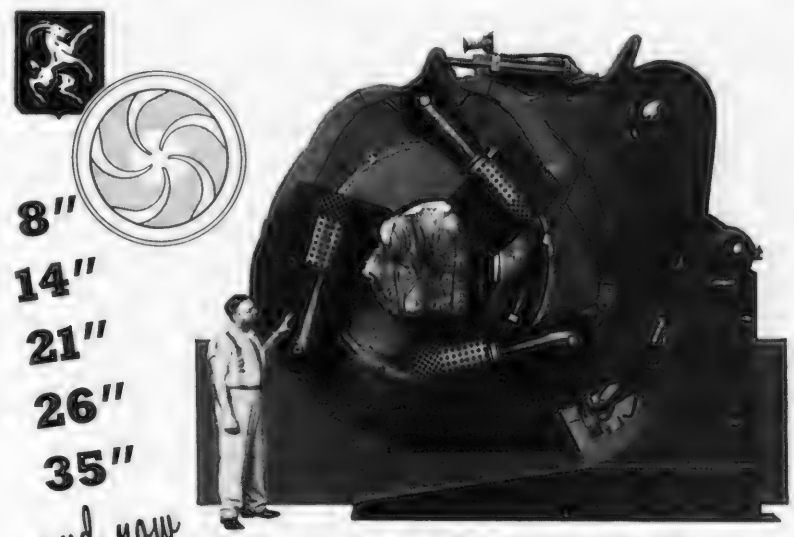
VI. New Officers for 1957–1958.

The following are officers for 1957–1958: A. S. Gregory, Chrm., I. A. Pearl, Vice Chrm., and F. G. Perry, Jr., Sec.

The meeting was adjourned at 10:25 A.M. by Chairman Locke.

VII. Attendance.

Attending the Chemical Utilization Division business meeting were: S. A. Woodruff, Battelle Institute; J. Allan Hauter, Allan Wood Products Co.; Mitsugn Yoshimura, Yale University; S. H. Wise, Wood Conversion Co.; A. S. Gregory, Weyerhaeuser Timber Co.; I. A. Pearl, The Institute of Paper Chemistry; T. E. Werkema, Dow Chemical Co.; J. M. Sayward, Norwich University; J. F. Ziegler, Arthur D. Little, Inc.; W. H. Koepp, Michigan College of Min. and Tech.; H. Dale Turner, Masonite Corp.; Wm. A. Kluender, C. & N. W. Railway System; J. K. Guiher, University of Illinois; C. S. Dosker, Gamble Brothers, Inc.; F. K. Beyer, University of Maine; Carl deZeeuw, N. Y. College of Forestry; M. Sarwat Husain, Pakistan Forest Research Service; E. Beglinger, U. S. Forest Products Lab.; E. Champagne, Central States For Exp. Sta.; R. B. Colgate, Black Dome Cork; E. G. Locke, U. S. Forest Products Lab.; F. G. Perry, Jr., Arthur D. Little, Inc.



...the largest, most powerful and efficient fully automatic barker ever built in the U. S.! Uses no pneumatics — requires no operator. Comes fully tested and ready to go. You supply only foundation and power to operate — save $10,000 installation cost as compared with competitive machines!

Eliminates problems with air compressor, air seals, and air line condensation and dirt. Well-tested tool tensioning device activated by rubber bands and hydraulic controls — can be changed by push button while in operation. Feed speeds also varied by push button controls. All moving parts completely sealed against dirt and automatically lubricated. Exclusive automatic bark cutter eliminates problems of stringy bark. Designed to meet any bark specifications, even on mixed hardwoods.

*Reg. U. S. Pat. Off. Numbers 2,623,558 2,738,996 2,775,274 2,785,715 2,786,499 2,787,384 2,788,034

90 installations in the U. S. and Canada have proved the Cambio's dependable performance

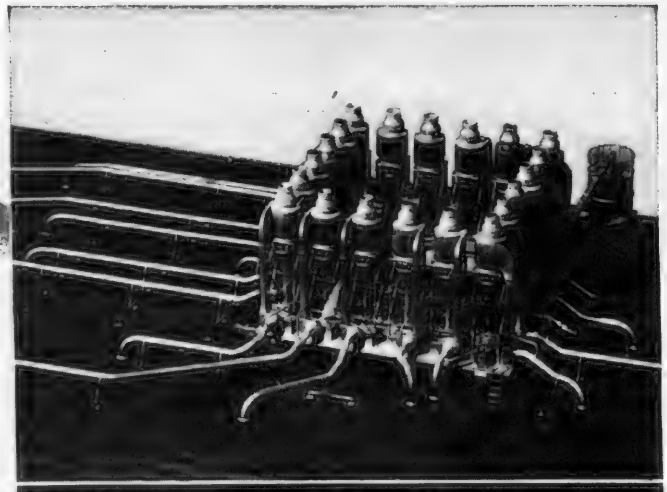
and new improvements have been added on pulpwood installations. Service follows through on every sale.

Your inquiries are invited.

SODERHAMN MACHINE MANUFACTURING CO.

SODERHAMN, SWEDEN SINCE 1864 TALLADEGA, ALABAMA

West Coast Sales Office: Room 409 Pittock Building, Portland, Oregon
East Canadian Representatives: Forano Limited, Montreal, Canada



PLASTIC MANUFACTURER: Exterior View of K & B Dust Control Installation

the dusty air that isn't there . . .

because of KIRK AND BLUM *dust control!*

Wherever you find woodworking equipment, a Kirk & Blum Dust Control system is likely to be working alongside, providing "clean air . . . the INVISIBLE tool" for increased production and improved working conditions.

Hundreds of leading woodworking plants have eliminated substantial waste by replacing old dust collecting systems with a modern Plenum Main type of system, exclusive Kirk & Blum development, or a streamlined Kirk & Blum Tapered Main System.

In more than 50 years of experience, Kirk & Blum Engineers have gained skill that can be used effectively in your plant . . . large or small. Call in a Kirk & Blum Engineer for a no-obligation survey.

PLYWOOD MANUFACTURER:
K & B Tapered Main Dust Control System

FURNITURE MANUFACTURER: K & B Plenum Main System

Write for the booklet "Blower Systems for Woodworking Plants."

KIRK AND BLUM
DUST CONTROL SYSTEMS

THE KIRK AND BLUM MANUFACTURING COMPANY, 3231 FORRER STREET, CINCINNATI 9, OHIO

CHEMICAL UTILIZATION DIVISION

INDUSTRY–EDUCATION DIVISION

GLUES AND GLUING—**Chairman, Alan A. Marra, University of Michigan, Ann Arbor, Mich.**

The meeting was called to order at 9:20 A. M. R. K. Stensrud served as secretary.

Dr. Marra opened the meeting with a discussion of organizational methods. Need for a definite membership was expressed, in opposition to the present dependence upon persons who attend the National Meeting and have an interest in glues and gluing. The chairman made a list of those attending to use as a membership list and as a source for future appointments to office.

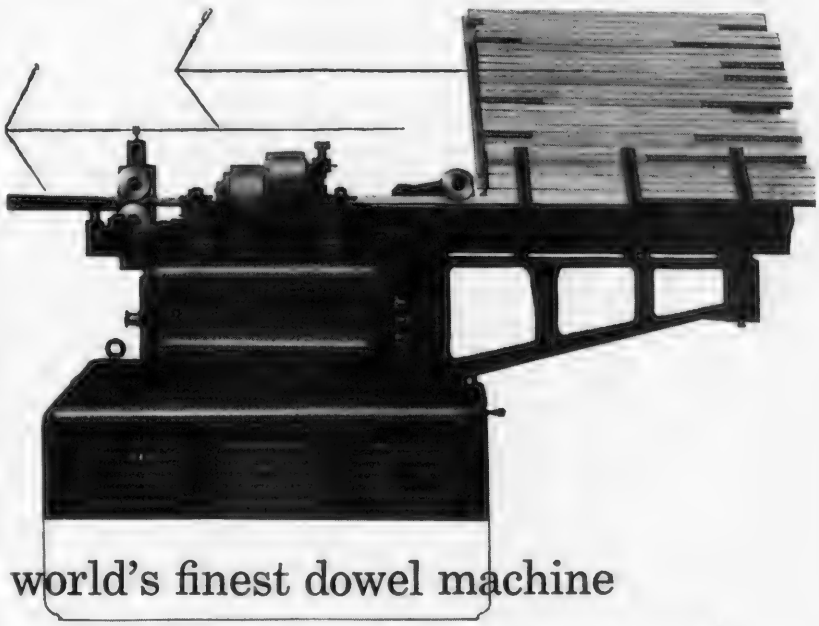
The following reports were given:

I. Adhesives—R. F. Blomquist, U. S. Forest Products Lab., chairman. Two new additions to the committee's study list were made. They are high-frequency (radio-frequency) adhesives, and composition board adhesives. Dr. Blomquist asked for indications from the membership regarding conflicts in the program such as two subcommittees of the division covering the same area of study. As vice-chairman of the Division, he requested suggestions for new areas of study for the National Meeting technical sessions.

II. Gluing Techniques and Glued Products—C. F. MacLagan, The Borden Co., chairman. It was decided that high-frequency gluing, and end-and-edge gluing should be added to this subcommittee's area of study. Mr. MacLagan proposed that inasmuch as many of the categories vary in different areas of the country, that he appoint a committee subchairman for various regions. He suggested the following appointments: J. M. Hine, The Borden Co. in Seattle, to cover all categories; A. H. Bishop, N. Y. State College of Forestry, Syracuse, all categories; J. S. Bethel, N. C. State University, all categories; M. J. Rhude, Unit Structures Co., Wis. and L. E. Clark, Jr., Perkins Glue Co., Pa., high-frequency gluing.

Mr. MacLagan suggested that the veneering section be broken down into softwood and hardwood because of the difference in gluing techniques used for these two types of woods. None of the appointments were confirmed at this time.

The question as to whether composition board binders should be considered in the subcommittee on Adhesives or Glue Techniques, or whether it should be separate section was brought up. It was decided to include it under Adhesives. A suggestion was made that regional representatives be appointed to handle this composition board phase of the Adhesives subcommittee.



world's finest dowel machine

new ruggedness, economy!

One man can keep the Hawker rod and dowel machine running at capacity all day long, with random length and out of square stock . . . at higher feed speeds! It's ruggedly constructed to modern precision machine tool standards; Timken tapered roller bearings throughout . . . solid steel cutter head.

Look at these outstanding features: minimum of vibration and chatter, no splintering—self-centering guide holds stock to within ½" of cutters. No twisting or spinning of dowel—vertically mounted outfeed rollers prevent it. Higher cutting speeds, better surface finish —variable stock feed drive.

High trade-in value for your old equipment on the new Hawker. Write for Hawker manual; demonstrations can be arranged. The Hawker Manufacturing Division, East Dayton Tool & Die Co., 1425 Keowee Street, Dayton 4, Ohio.

HAWKER

PRODUCTION MACHINES FOR WOOD, DOWEL, CHUCKING, SPECIAL

Columbia HOT PLATE PRESSES

15 FEATURES Save in Service

Every feature of Columbia Hydraulic Hot Plate Presses has been designed, perfected and proved for smoother operation, superior production, higher efficiency, economy and durability. Even in routine operation, these features make better production easy to attain.

Shielding for flexible hoses shown on above 16 daylight hot plate press —optional extra

- **SUPER-RIGID CONSTRUCTION** for trouble-free service
- **CAST STEEL CYLINDER AND STEEL ALLOY RAM** for minimum maintenance
- **IMPROVED HYDRAULIC SYSTEM** for quick closing, accurately maintained pressure
- **EXCLUSIVE COLUMBIA PLATEN SPACER** for extra rigidity, strength and safety
- **AUTOMATIC PRESSURE TIMING** for absolute product uniformity
- **PRECISION TEMPERATURE CONTROL** for utmost operating efficiency and accuracy
- **TROUBLE-FREE STEAM FEED SYSTEM** for long life with minimum maintenance
- **READILY ACCESSIBLE PACKING** for easy replacement
- **AUTOMATIC AIR-BLEEDING** for convenient and positive operation
- **LEAK-FREE PLATEN DESIGN** for easy clean-out of sediment or scale
- **FLEXIBLE HOSE STEAM PLATEN CONNECTIONS** eliminate mechanical troubles
- **STEAM LINES PROTECTED** from accidental damage
- **LEAKPROOF WELDED HYDRAULIC PRESSURE SYSTEM** positively assures full pressure
- **FASTER, MORE UNIFORM HEATING** with special platen design
- **CONVENIENT REMOTE CONTROL** with floor-mounted panels

Want further details?
Write today for Bulletin HP-15.
The Lodge & Shipley Co., 3063 Colerain Ave., Cincinnati 25, Ohio.

Lodge & Shipley

....your LODGE-ical choice!

LOGGING DIVISION

LUMBER MANUFACTURING DIVISION

III. Methods of Test—John Butler, Hardwood Plywood Institute, chairman. Whether or not a section covering hardwood overlaid plywood should be set up was discussed. Mr. MacLagan suggested that combination materials of the subcommittee on Glue Techniques would cover this category. The committee on specifications, it was said, would report on and review specifications in the Annual Review.

Dr. Blomquist, chairman of Committee D-14 of the American Society for Test Materials (Committee on Adhesives), reported that a meeting was recently held to increase activities. He said a new subcommittee on wood adhesives was established with the intention of reviewing and revising old test methods, developing new methods, and setting up specifications for adhesives as such, rather than end-use tests of glued products such as are now used. The West Coast Adhesive Manufacturers Technical Committee, through R. K. Stensrud of Reichold and J. R. Ash of Monsanto, offered to work as a group on this D-14 subcommittee.

The importance of testing techniques such as speed of cross-head movement in the block shear test was discussed in regard to the exterior testing of particle board under ASTM tentative methods originally based on work at the National Bureau of Standards on building fiberboards. It was pointed out that none of the phenolic-bound chipboards could pass this test at present. A report on this subject will be made in the Annual Review.

IV. Gluing Equipment—R. W. Williams, American-Marietta Co., chairman. In Mr. Williams' absence, L. S. Miller reported. Inasmuch as gluing equipment varies considerably from region to region, it was suggested that regional representatives be set up on this committee. A breakdown under this committee would show each of the gluing techniques shown under the committee on Gluing Techniques since spreading, and pressing, and so forth, vary considerably with each gluing technique. It was suggested that equipment manufacturers be contacted for current data on gluing equipment.

V. Current Research—J. S. Bethel, N. C. State University, chairman. Dr. Bethel proposed regional representatives to this committee. He thought that this would cover the same areas and personnel who are solicited for information by the other committees, but suggested that persons in these other areas do not solicit information on research as such.

SARANAC Machines* can help
SOLVE YOUR PACKAGING PRODUCTION PROBLEMS!

FOR SHORT RUNS—OR SMALLER PLANTS—CHOOSE A GENERAL PURPOSE STAPLER

A heavy-duty machine, the General Purpose Stapler pays off on short or medium runs. With one or two stapling heads, it'll make *stronger* crate parts *fast,* handling a wide variety of jobs. Makes and drives its own staples direct from coils of low-cost wire. *Request Bulletin 166.*

FOR MEDIUM OR LARGE VOLUME RUNS, SELECT A CHAIN-FEED SARANAC!

For example, this chain-feed Saranac C R Machine delivers astonishing production in large plants. With a crew of 8 people, it produces 100 linear feet of cleated box panels per minute, replacing equipment costing $50,000 *more* and requiring a crew of 29 people. *Request Bulletin 167-CR.*

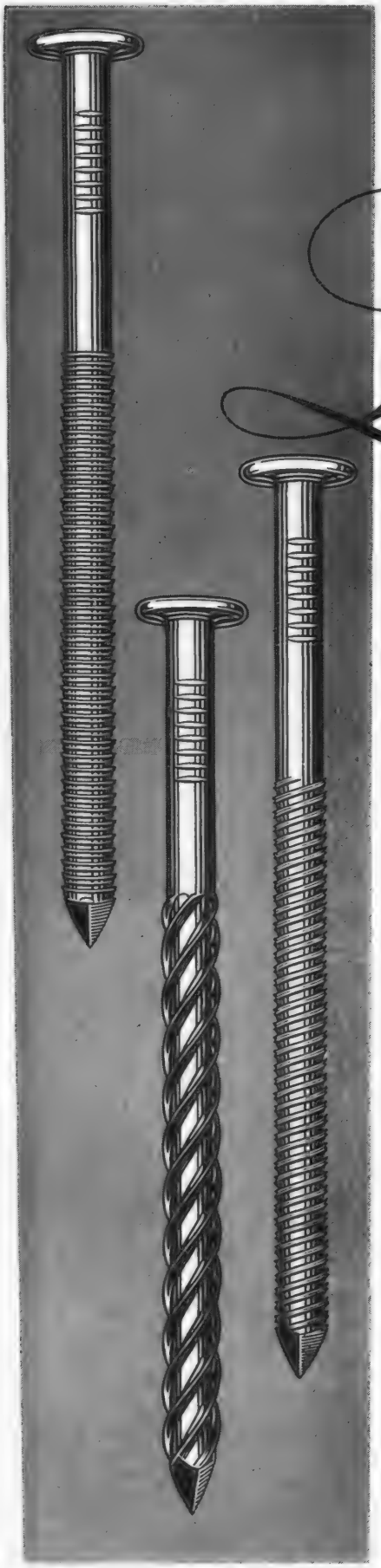
*A WIDE RANGE OF TYPES, SIZES . . .

Between these extremes in size and capacity, Saranac builds hundreds of models of hand-feed and chain-feed container-making machines. All cut, form and drive their own staples direct from low-cost coils of wire available almost anywhere. All offer you the greater holding power of rugged, clinched staples—and the greater dependability of Saranac-engineered design.

Write Saranac, describing your container-making problems. Send samples if possible. We'll gladly make suggestions without obligation.

SARANAC MACHINE COMPANY
BENTON HARBOR • MICHIGAN

Manufacturers of the World's Largest Line of Fastening Machinery



THE **Stronghold** *Line* ®

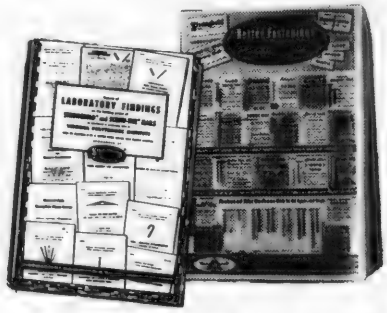
BETTER FASTENINGS FOR EVERY PURPOSE

Leadership

IN BETTER FASTENINGS

Improved fastenings, pioneered and developed by Independent, have revolutionized construction methods. STRONGHOLD Annular Thread, STRONGHOLD Screw Thread and SCREW-TITE Spiral Thread Nails provide the effective holding power of wood screws, yet they drive with all the ease and speed of ordinary nails. Scientifically engineered threads "lock" with the wood fibres; STRONGHOLD and SCREW-TITE Nails hold tight—stay tight—*increase in holding power after driving*, as the wood into which they are driven seasons. STRONGHOLD and SCREW-TITE Nails add strength to the structure, make improved nailing techniques feasible, eliminate maintenance and repairs commonly encountered with ordinary smooth nails, often permit substantial savings in time, labor, fastener costs and materials. Write us for complete information.

● The vastly greater holding power of STRONGHOLD and SCREW-TITE Threaded Nails has been conclusively proved by continuing scientific laboratory testing under our sponsorship at Wood Research Laboratory, Virginia Polytechnic Institute, Blacksburg, Va. Write for reports giving test data and findings. Just ask for "V.P.I. Bulletins."



STRONGHOLD and SCREW-TITE Nails are made in all styles in regular or hardened steel, copper, brass, commercial bronze, silicon bronze, aluminum, Monel and stainless; any length to 9 inches, any gauge to .310; any style head or point; plain, hot galvanized, electroplated, or special finishes, including baked lacquer in matching colors.

© 1957 I. N. & P. Co. "Stronghold", "The Stronghold Line", "Screw-Tite", Trade Marks Reg. U. S. Pat. Off.

There is only one STRONGHOLD Line—the Original. Made only by

INDEPENDENT NAIL & PACKING CO

Pioneer Developers and Largest Manufacturers of Threaded Nails

BRIDGEWATER, MASSACHUSETTS, U.S.A.

MEMBER: PRODUCERS' COUNCIL *and* BUILDING RESEARCH INSTITUTE

VII. Bibliography—B. S. Bryant, University of Washington, chairman. In Dr. Bryant's absence, a report was given by R. K. Stensrud, Reichhold Chemicals, Inc. Copies of a 1956 bibliography prepared by Dr. Bryant were distributed and Mr. Stensrud outlined the methods used in its preparation. Suggestions were that the committee be composed of the chairmen of the other committees in the Division, plus the Division Chairman, P. Northcott, Forest Products Lab. of Canada, R. E. Currier, Oregon Forest Products Lab., and Joseph Marian, University of California Forest Products Lab.

It was proposed that the Oxford System be considered a source of bibliographical information and that patents be included in the bibliography.

VIII. Technical Session—R. F. Blomquist as Division vice-chairman reported on the subject matter of the 1957 Technical Session and announced that a panel discussion would take place in which industry members could talk "off-the-cuff". None of the panel remarks were to be published. Two technical papers were also scheduled. It was moved, seconded and passed that the division sponsor a technical session in 1958.

New Officers for 1957–58.

Officers appointed for the 1957–58 year were: R. F. Blomquist, U. S. Forest Products Lab., Madison, Wis., chairman; B. S. Bryant, University of Washington, Seattle, Wash., vice-chairman and in charge of Technical Session for 1958; and Carl F. MacLagan, The Borden Co., Bainbridge, N. Y., permanent secretary. Dr. Blomquist outlined plans for continuation of the work of the Division and asked for cooperation of the membership as a whole for the next year.

Subcommittees and Sections of the Division.

I. Adhesives—a) plywood adhesives, b) assembly adhesives, c) laminating adhesives, d) dissimilar-materials adhesives, e) extenders, f) modifiers, g) selection and performance, h) high-frequenecy adhesives, i) composition-board adhesives.

II. Gluing Techniques and Glued Products—a) veneering, b) laminating, c) assembling, d) combination materials (paper-faced lumber and plywood decorative overlays, etc.), e) high-frequency gluing, f) end-and-edge gluing.

III. Methods of Test—a) strength tests, b) accelerated durability tests, c) long-time durability tests, d) service observations, e) specifications.

IV. Gluing Equipment—a) storage and handling, b) mixing, c) spreading, d) pressing, e) heating (including high frequency).

V. Current Research—a) basic research relating to wood, b) basic research relating to adhesives, c) development research.

VI. Patents.

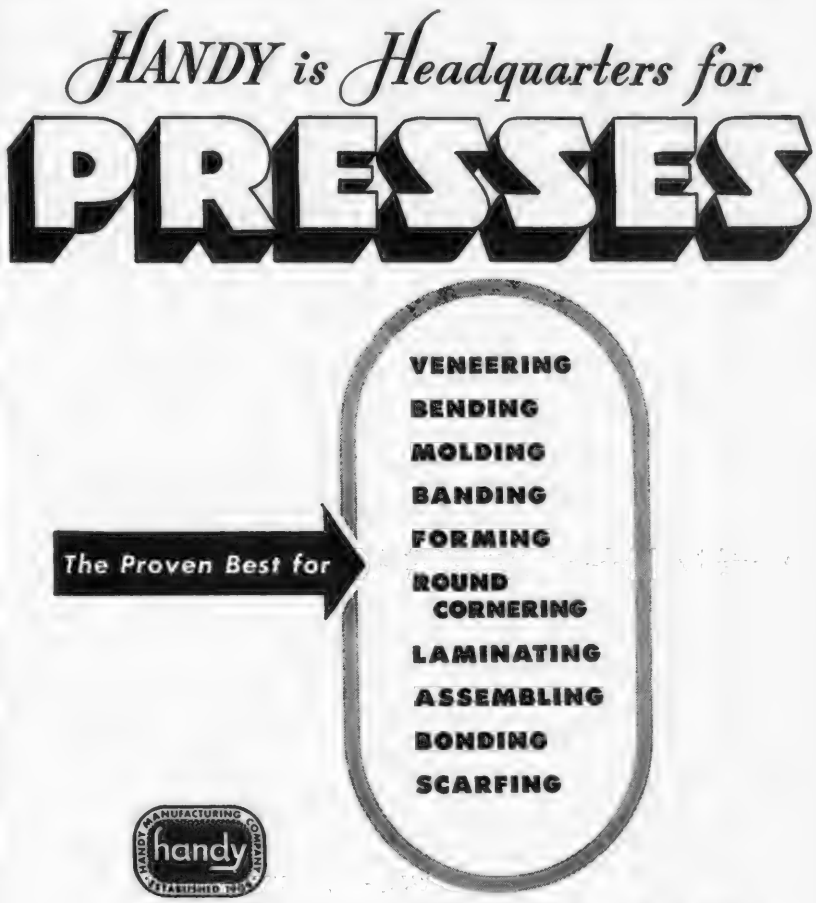
VII. Bibliography—a) books, b) articles.

VIII. Technical Session, 1958.

IX. Annual Review.

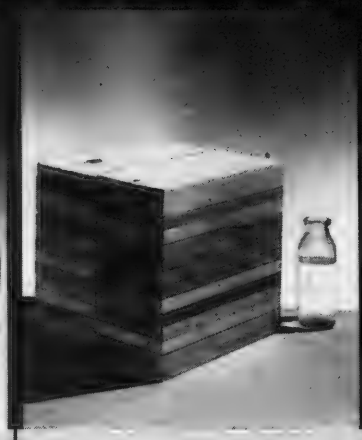
Attendance.

The division meeting was attended by: A. A. Marra, University of Michigan; C. C. Campbell, Olin Mathieson; R. C. Gill, Peter Cooper Corp.; R. F. Blomquist, U. S. Forest Products Lab.; Wm. P. Johnson, The Borden Co.; C. Curtis Booth, Borden Co.; C. L. MacLagan, The Borden Co.; F. M. Kujawa, Durez Plastics; E. A. Grant, Franklin Glue Co.; R. F. Snider, Franklin Glue Co.; LeRoy P. Wahl, Archer Daniels Midland; A. H. Bishop, N. Y. State College of Forestry; H. A. Huber, The Dow Chemical Co.; R. W. Wellwood, University of British Columbia; H. C. Moser, Gamble Bros., Inc.; G. E. Olson, The Dow Chemical Co.; N. V. Poletika, Timber Engineering Co.; R. S. Burnett, Wilson & Co., Inc.; J. R. Ash, Monsanto Chemical Co.; H. E. Troxell, Colorado State University; G. T. Butts, Colton Chemical Co.; R. H. Bergstrom, The L. F. Dettenborn W. W. Co., L. S. Miller, American-Marietta Co.; W. T. Nearn, Penna. State University; J. S. Bethel, N. C. State College; J. F. Hamilton, Michigan College of Mining and Technology; and R. K. Stensrud, Reichhold Chemicals, Inc.


HANDY is Headquarters for
PRESSES
The Proven Best for
VENEERING
BENDING
MOLDING
BANDING
FORMING
ROUND CORNERING
LAMINATING
ASSEMBLING
BONDING
SCARFING
HANDY MANUFACTURING COMPANY
handy
ESTABLISHED 1924
no matter what the job . . . Handy builds the right press for you: hydraulic, air-powered or screw-operated; hot platen or cold; small or large—but always to produce for you at highest efficiency and lowest cost. Airmail at once, giving details.
THE NEW HANDY AIR-DRAULIC POWER PRESS IS MAKING BIG NEWS
HANDY Manufacturing Company
2442 WEST LAWRENCE AVENUE • CHICAGO 25, U. S. A.

NOW IS THE TIME TO ACT TO PREVENT WINTER'S DRY AIR LOSSES

1.
RELATIVE HUMIDITY 60%. Assume the windows are open in your plant. It's a warm day and relative humidity is 60%. A cubic foot of wood in your plant holds nearly 3½ pints of water. Now see 2.



2.
RELATIVE HUMIDITY 10%. A cold snap drops outdoor temperature to 20°F, 75 RH. Heat your plant to 75°F and the wood losses nearly 3 pints of water to the dry indoor air.

3.
QUICK DROP CAUSES THIS! The wood shrinks as it loses moisture, setting up stresses that cause cracking, checking, warping—(losses that, each year, will more than pay for Armstrong Steam Humidifiers.

Install ARMSTRONG STEAM HUMIDIFIERS ...let them pay for themselves through savings this year

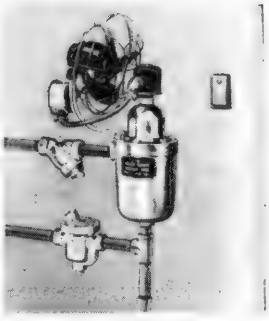
The photos above tell the story, the results of which you will probably see repeated in your plant this winter—unless you humidify. Install humidifiers *now,* and you can prevent *any* dry air loss.

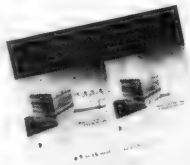
Armstrong Steam Humidifiers give you many advantages. They discharge steam directly into the room. Since steam is distilled water in the form of a gas, there is no mineral or moisture "fall-out".

Installation is easy—similar to unit heaters. Controlled by sensitive humidistats, Armstrong Steam Humidifiers give accuracy within 2 to 4% of setting. The simple, sturdy design makes for negligible maintenance. They work for pennies a day, and commonly pay for themselves in one season.

Armstrong Steam Humidifiers are so proved in service that they are *unconditionally guaranteed* to satisfy—on a money-back basis.

AUTOMATIC •
ACCURATE •
TROUBLE-FREE •
LOW COST •
HIGH CAPACITY •
CLEAN •
GUARANTEED •





BULLETIN GIVES THE FACTS ON HUMIDIFICATION IN WOODWORKING

Bulletin 505 tells: Importance of humidification in modern woodworking . . . how relative humidity affects woodworking . . . advantages of Armstrong steam humidification . . . benefits obtained by present woodworking users. To get your copy, call your Armstrong Factory Representative, or send the handy coupon today to:

ARMSTRONG MACHINE WORKS
9561 Maple Street
Three Rivers • Michigan

Armstrong Machine Works
9561 Maple Street
Three Rivers, Michigan

Send me a copy of Bulletin 505

Name_____

Attach to company letterhead and mail.

INDUSTRY - EDUCATION—Chairman, A. J. Panshin, Michigan State University, East Lansing, Mich.

Chairman Panshin opened the meeting with a review of activity on brochures designed to reach high school students. A discussion followed concerning the joint efforts of FPRS and NLMA to develop brochures to interest high school students in wood-industry careers. It was pointed out that colleges are not producing enough men to fill the needs of industry and that among the main problems is the lack of knowledge that students have concerning careers in the wood industry. (*Note:* A full report of the discussion held will be published in a near future issue of the JOURNAL).

At the summation of the discussion, members of the NLMA subcommittee concerned with attracting high school students to the wood industry said that necessary steps would be taken to invite the FPRS group to a joint meeting in November.

A report on a survey of "working" wood technologists was made. Results discussed were published in the February 1957 issue of the JOURNAL.

Plans for the 1958 National Meeting.

Five subjects for papers to be given at the 1958 National Meeting were suggested. They are: education of producers; education of designers and consumers; student education; professional education; and industry and association educational methods.

The possibility of requesting a full day for the program was discussed. Another consideration was to have a panel of five members, limiting each to 20 minutes presentation and 20 minutes in discussion. Other suggestions were that the session start at a luncheon with a speaker to introduce the panel, and that the business meeting be held in the morning, with the technical session in the afternoon.

LOGGING—Chairman, F. C. Simmons, Northeastern Forest Experiment Station. Upper Darby, Pa.

I. Objectives, Organization and Activities.

Mr. Simmons opened the meeting with a report explaining the formation of the Logging Division. He stated that this was the first meeting since the Division had been formed last year by the splitting of the Logging and Milling Technical Committee of the Society. The Divisional setup, rather than the Technical Committee setup, resulted from the meeting at Asheville in 1956. He enumerated other forest products besides sawlogs that logging includes, among which were veneer, pulpwood, poles and piling.

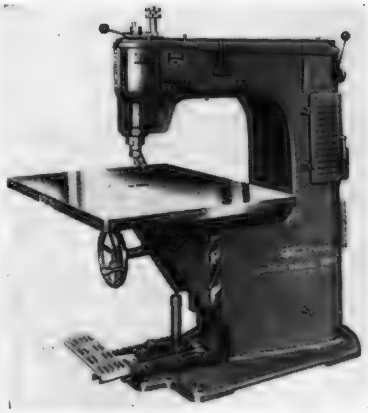
II. Geographic Representation.

An attempt to provide representation of logging regions was made in setting up the Steering Committee. It consists of Fred C. Simmons, Upper Darby, Pa., chairman; Paul M. Dunn, New York City, vice-chairman; R. A. Gustafson, Georgetown, S. C.; Bruce Mety, Warren, Ark.; David Herrick, Carbondale, Ill.; Leland Hooker, Houghton, Mich.; William McGraw, Toronto, Ont.; J. A. Doyle, Ottawa, Ont.; E. E. Matson, Portland, Ore.; and Myron Krueger, Berkeley, Calif. Discussion was held on the possibility of having members to represent western Canada, the northern Rocky Mountains, the Southwest, and the Gulf Coast on the Steering Committee.

III. Functions of the Steering Committee.

Duties of the Steering Committee that were outlined included the preparation of the annual report on developments in the subject matter field for publication in the Forest Products Journal; development of the program for the technical session at the annual meeting of FPRS; the answering of inquiries coming to the Society in the subject matter field; review of papers submitted for publication in the JOURNAL, and cooperation with Sections of the Society and local organizations such as Loggers' Congress and technical committees of the American Pulpwood Association.

Onsrud



machines to increase... production and profits

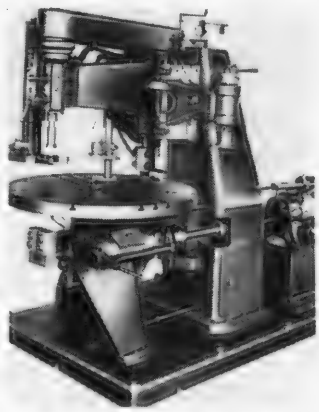
Let us give you the facts about today's modern Onsrud machines for high speed, lower cost woodworking. Faster feeds, more automatic controls, patented Onsrud design features are a few of the many advantages new Onsrud machines will give you.

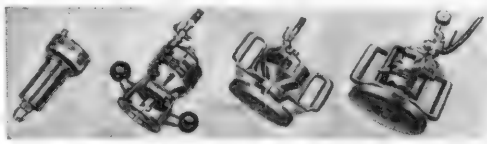
ONSRUD HEAVY DUTY ROUTERS
Built to handle any routing job in woodworking. Practical for both light, medium and heavy duty work. Low cost patterns, real power, easy adjustment and control save you money in set-up and production. Precision spindles operate at 10,000 and 20,000 RPM. Supplied with 24" or 30" throat clearance, as W-244 or W-304 Routers.

ONSRUD W-180 MEDIUM DUTY ROUTER
When you want a lower cost router for light or medium work, here's a precision machine built for years of trouble-free, dependable service. A smaller machine for smaller work, with all of the quality and speed for larger routers.

ONSRUD AUTOMATIC SHAPERS
For fully automatic shaping production at high speed and precision. Now available in wide range of capacities, with single or double arms, and belt drive and direct drive. Complete service in pattern design and construction.

ONSRUD W-28 DUAL TABLE AUTOMATIC SHAPER
Turning capacity up to 28". Two rotating work tables give continuous, high speed production. While one table is stopped for load ad unload, second table feeds work to cutter.





ONSRUD PORTABLE ROUTERS
Choice of eleven models from ¼ to 5 HP . . . with spindle speeds up to 50,000 RPM. Cool running, powerful air turbine and electric motor drives.

WRITE FOR FREE BULLETINS
Bulletin 1134—W-244 and W-304 Heavy Duty Routers.
Bulletin 1135—Medium Duty Router.
Bulletin 1101—Automatic Shapers.
Bulletin 1123—Dual Table Shaper.
Bulletin 1137—Heavy Duty Shaper.
Bulletin W-200—Medium Hand Shaper.

ONSRUD MACHINE WORKS INC. WOODWORKING DIVISION
3954 PALMER STREET • CHICAGO 47, ILLINOIS

MORE FROM THE TREE

...and MORE FOR YOUR DOLLAR

Since the century began, Gamble Brothers has been in the forefront of efforts to secure maximum utility from our nation's valuable hardwoods—through proper application of grades and species to function, through planned conversion practices, through engineered shapes and dimensions, and through dependable lamination. Improved utilization leads to greater economy.

Our league-leading team of wood engineers works constantly in our laboratories and in the field to increase the economic usefulness of wood. Our 23-acre plant hums daily with the production of hardwood parts and dimension stock, and engineered wood and wood-combined materials.

If you believe some of our effort spent on your behalf could be of aid to you, please talk it over with us. We'd like to help.

GAMBLE BROTHERS, INC.

4601 Allmond Avenue
Louisville, Kentucky

For a *truly* good floor

NORTHERN HARD MAPLE

truly economical

truly modern

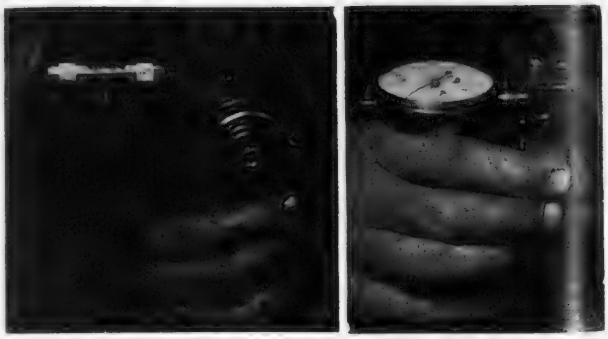
truly resilient

★

MAPLE FLOORING MANUFACTURERS ASSN.

CHICAGO 1, ILLINOIS

NOW! Take the "Guesswork" Out of Veneer Cutting!



TWO NEW INSTRUMENTS, a precision angle indicator and horizontal opening indicator, eliminate "rule of thumb" methods for setting the angle of the knife and the horizontal opening between knife edge and nosebar on veneer lathe or slicer.

SINCE introducing these 2 new tools for precision cutting of veneers in January, they have been ordered and put into use in both softwood and hardwood veneer plants in every section of the U. S. and Canada — from British Columbia to South Carolina, from California to Ontario.

At a recent meeting one producer observed, "It doesn't make any difference how experienced the operator, there comes a time when he gets into trouble for some reason or other and he just can't get back. If he has some standards such as these instruments, they would help him correct his trouble."

With these instruments, even a novice can make accurate adjustments on lathe or slicer and cut good veneer consistently.

For literature and prices write:

WFM WISCONSIN FOUNDRY AND MACHINE COMPANY

623 E. Main ST. Madison, Wis

IV. Classified Bibliography Undertaken.

The general consensus was that the most useful and practical project that might be undertaken by the Steering Committee and members of the Division would be the preparation of a basic and classified bibliography of significant literature in logging over the past several years. The Chairman was instructed to obtain reference material for such a bibliography from the Department of Agriculture Library in Washington, D. C., and to distribute it to committee members and others for selection, and possible annotation. Other projects suggested were compilation of state safety legislation pertaining to logging, preparation of a list of needed research projects in logging, and periodic interim reports on new developments. These were deferred for future consideration.

V. Attendance.

Those present at the meeting were: F. C. Simmons, Northeastern Forest Exp. Sta.; Arthur G. Horn, Lake States Forest Exp. Sta.; Paul H. Lane, Lake States Forest Exp. Sta.; David E. Herrick, Central States Forest Exp. Sta.; A. B. Recknagel, St. Regis Paper Co.; Lowell Besley, Pulp & Paper Res. Institute of Canada; Paul Heller, Pacific Pine Co. Ltd.; Orvel A. Schmidt, Penna. State University; Richard F. West, Rutgers University; Milton H. Mater, Mater Engineering Co.; Siegfried Tolle, Northeast Wood Products; K. O. Roos, Booth Lumber Ltd.; J. B. Veach, Jr., Bemis Hardwood Lumber Co.; K. C. Compton, N. Y. State College of Forestry; Don MacCrae, Connor Lumber & Land Co.

LUMBER MANUFACTURING—Chairman, Milton H. Mater, Mater Engineering Co., Corvallis, Ore.

Chairman Mater introduced Pete Johnson, California Redwood Assoc., and appointed him recording secretary for the session.

The minutes of the previous year's Division meeting and the minutes of the May 1957 meeting of the Pacific Northwest Section of the Lumber Manufacturing Division were read.

I. Field Research Questionnaire.

Prepared by a sub-committee headed by Mr. Bye, the questionnaire is designed to ascertain what industry wants from research and how they are currently gaining this information in the field of lumber manufacture. Mr. Bye reported that several questionnaires were sent to firms during the year for approval of question type and wording.

The three general questions were: 1. What specific problems in the sawmilling industry do you think need to be solved at the present time? What benefits do you think would result to the sawmill operator from progress in working out these problems? 2. What information would you like to have made available to the sawmill industry and how would you use this information? 3. What are your present sources for obtaining this type of information? a) Which technical society publications do you read? b) Which trade publications do you read? c) What equipment manufacturer's information is available to you? d) In what direct research programs do you participate?

Mr. Bye was again appointed to carry on with his sub-committee to complete the questionnaire.

II. Mechanical Improvements Queried.

In the absence of Mr. Ivory, Mr. Mater reported on the progress of the return postcard questionnaire. It was designed to find out about mechanical improvements in the sawmill industry as a whole. When returned, the questionnaires will be screened by the committee and, after permission from the respective companies involved is obtained, the results will be published in the JOURNAL. Prof. K. Compton was appointed head of this sub-committee and asked to complete the project.

III. Other Business.

Mr. Mater discussed the subject of sawmill nomenclature, reporting that

Have you seen the new 6-FOOT BAND MILL By ENTERPRISE?

FAST . . . RIGID . . . VIBRATIONLESS . . . EASY TO OPERATE

New Simple Strain Mechanism

Sensitive . . . fast-reacting . . . with less friction . . . no columns to move . . . no knife-edges to maintain

Low-Friction Wheel Raise

Totally-enclosed . . . effortless . . . fast . . . even more of a breeze with a raise motor, furnished at slight extra cost

Right or Left Hand Mill

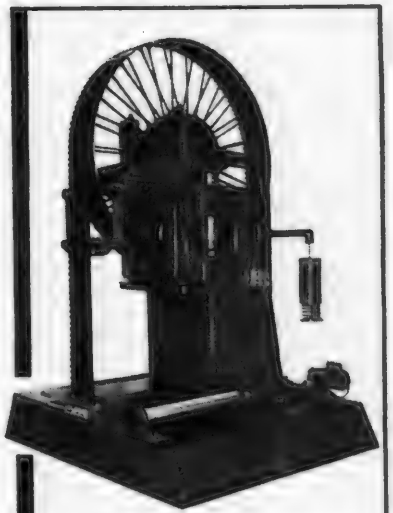
Can be changed at any time without new parts or machining of components

All-Welded Steel Frame

2½-times as rigid as cast iron of equal thickness

Anti-Friction Bearings Throughout

Non-rotating 4½-in. Top Wheel Shaft. Heavy Timken Bearings inside upper wheel



This is the well-known Sinker-Davis "Hoosier" mill, purchased by Enterprise and re-engineered for the modern sawmill.

Enterprise is your source for completely-engineered sawmills, and sawmill components —including Enterprise steel or all-aluminum automatic carriages.

ESTABLISHED 1870

THE ENTERPRISE COMPANY

Columbiana, Ohio • "Since 1878"

NEWMAN K-16 Tilting Arbor VARIETY SAW

Rips to 48" wide

DESIGNED for YOUR PROFIT

Micrometer double faced rip fence with rack and pinion adjustment permanently aligns fence with saw blade and allows cuts to full 48" wide. Handwheel locks both sides of fence simultaneously. Guard and splitter automatically tilt with saw blade. Guard has anti kickback fingers. All cast iron base and table. Direct connected 3600 R. P. M. 5 H. P. motor. Full 45° tilt of saw with positive lock for holding tilt. Delivery from stock subject to prior sale. Write for descriptive literature and complete quotation.

NEWMAN MACHINE COMPANY, INC.
GREENSBORO, NORTH CAROLINA, U. S. A.

Promote CONSERVATION

Through PRESERVATION

— BY USING —

"Black Beauty" Products

TEXAS CREOSOTING COMPANY
Orange, Texas

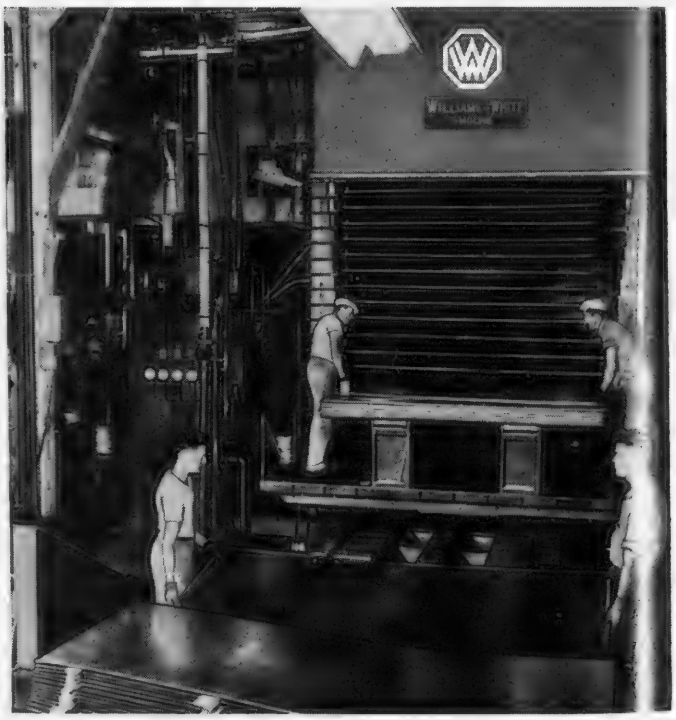
WILLIAMS-WHITE HOT PLATE PRESSES

For Better Products

An excellent WILLIAMS-WHITE Hydraulic Hot Plate Press installation is shown in the photograph at right. Whether producing 12" x 12" or 48" x 192" panels, the experience accumulated in building hydraulic hot plate presses since 1933 becomes an integral part of each WILLIAMS-WHITE Press furnished to the plywood, particle board or allied industries. We invite you to discuss your requirements with us before you buy. Write for complete information.

The press illustrated is a 20 opening, 1,484 ton, 106" x 56" WILLIAMS-WHITE Hot Plate Press in the GPX Plastic Surfaced Plywood operation in the Olympia, Washington, plant of Georgia-Pacific Corp.

BUILDERS OF MACHINERY SINCE 1854



WILLIAMS-WHITE & Co.
401 EIGHTH ST • MOLINE ILLINOIS
PRESSES • BULLDOZERS • BENDERS • PUNCHES • SHEARS

Representatives:
ALLIED NORTHWEST MACHINE TOOL CORP., Portland, Ore.
GEORGE A. DAVIES, JR. MACH'Y. CO., Los Angeles, Calif.
PERINE MACHINERY & SUPPLY CO., Seattle, Wash.
WILLIAMS-WHITE & CO., 53 W. Jackson Blvd., Chicago

a section of the Milton H. Mater–David P. Thomas text on Sawmilling will contain a nomenclature list, which is being compiled now.

A short abstract on Section papers to be presented at the technical session was given by Mr. MacRae and Mr. Mater.

Mr. K. C. Compton gave a report on the Northeastern Area.

Chairman Mater informed the membership that a request had come to the Division to form a region covering Louisiana, Arkansas, Oklahoma, and East Texas. It was moved, seconded and unanimously voted that the new area be adopted.

After a short discussion on the length of office for committee chairmen, Mr. Mater was asked to serve as chairman for another year.

Discussion was held on the official name of the Division, and it was decided that the name, Lumber Manufacture Division, be left as is.

IV. Measuring Lumber for Quality Control to be Studied.

After the technical session, Paul Heller moved that a new project to determine the best method of measuring lumber for quality control be undertaken. Questions to be answered are:where on the piece is it best to measure the lumber? How many measurements should be taken on a piece, etc.? The meeting was reconvened to consider this motion. It was seconded by Mr. Bye and unanimously approved. Mr. Mater will appoint a sub-committee during the year to handle this project.

V. Attendance.

Those attending the meeting were: K. C. Compton, N. Y. State College of Forestry; William Shields, H. K. Porter Co.; David E. Herrick, Central States For. Exp. Sta.; Robert Hoyle, N. Y. State College of Forestry; F. P. Loveland, F. P. Loveland & Associates; Paul Lane, Lake States Exp. Sta.; K. O. Roos, Booth Lumber, Ltd.; G. B. Gillies, Gillies Bros. & Co., Ltd., Fritz Tolle, Northeast Wood Products, Inc.; D. M. MacRae, Connor Lumber & Land Co.; N. C. Bye, H. K. Porter Co.; James L. Lubkin, AMF Central Research Lab.; Tony Veasey, Anaconda Co.; M. H. Mater, Mater Engineering Co.; Paul Heller, Pacific Pine Co. Ltd.; Pete Johnson, Calif. Redwood Assoc.

MARKETING—Chairman, Robert Pauley, Weyerhaeuser Timber Co.

Chairman Pauley opened the meeting and Gerald H. Smith served as Secretary.

I. Goals.

Since there appears to be general recognition of the importance of marketing as encompassing and affecting the entire range of activities from procurement through production, distribution, and ultimate consumer satisfaction, the group considered at length the direction and scope of activities with which the Division might be concerned, and which might be effectively implemented.

Discussion was held covering the following points: the study of function and use requirements as related to products research, and as a guide to testing methods; the question of concentration upon industrial rather than consumer markets; the matter of industry-wide marketing problems as opposed to regional or other competitive influences within the lumber and wood products industry; the use of market and marketing research as a means of exploiting the promising results of technical research; and the possibility of attempting some type of market survey or reporting service, a need which may now be adequately met by associations and trade publications.

II. Division Objectives.

Division objectives were formulated as follows: "To aid in the maintenance and expansion of forest product markets by encouraging research in any areas likely to contribute information useful to the entire merchandising program. Such efforts might include studies of end-use requirements, market potential, distribution patterns, merchandising methods, or other appropriate fields of investigation."

WILLIAMS "No-Nife" HOGS

Make better fuel from wood scrap . . . . and save money!

Burning scrap in jumbled lengths and odd-shaped pieces wastes heat value (BTU's) . . . restricts air flow . . . causes uneven combustion . . . smothers fire . . . creates excessive smoke . . . increases handling time up to four times.

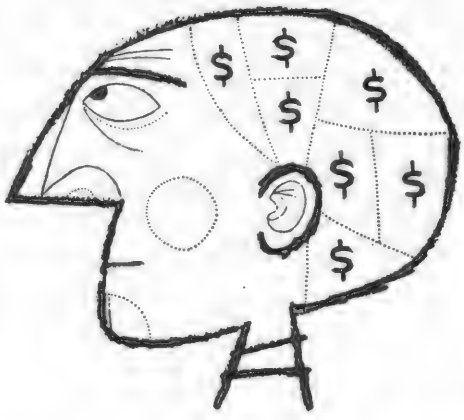
Proper reduction to chips in a Williams Hog yields maximum heat value . . . keeps smoke at a minimum . . . lets one man handle as much in chips as three or four men handle in unhogged scrap.

A Williams *Automatic Installation* pays for itself in a few months.

Write for Illustrated Brochure

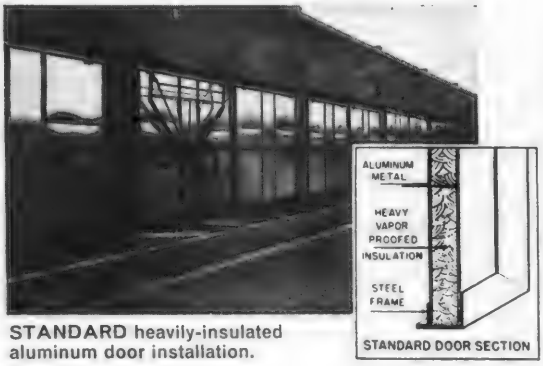
WILLIAMS PATENT CRUSHER & PULVERIZER CO.
816 ST. LOUIS AVE. • ST. LOUIS 6, MISSOURI

WILLIAMS
CRUSHERS GRINDERS SHREDDERS
OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD



money on your mind?

You'll be money ahead when you **replace your old wooden doors with STANDARD Heavily-Insulated Aluminum Doors** . . . a sure way to put more profits in your pockets! Rust-proof, tight-fitting, and with an insulation value equivalent to a 13" brick wall, STANDARD aluminum doors permit faster, more uniform drying, eliminate fuel waste, and cut down your insurance rates. Get the facts, now!



STANDARD heavily-insulated aluminum door installation.

send us your door sizes, and we'll rush figures on

Standard

ALUMINUM DOORS!

STANDARD DRY KILN COMPANY

P. O. Box 5708 • Indianapolis 21, Indiana

Cascades Plywood Corporation

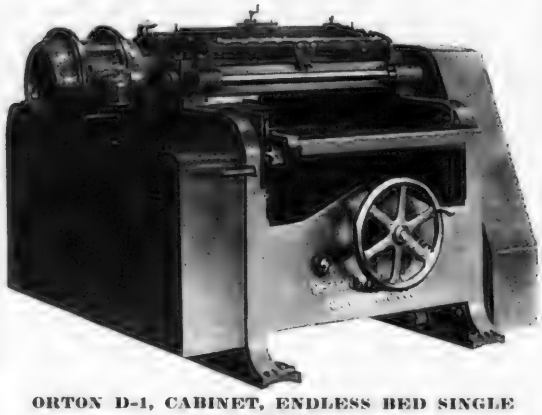
Manufacturers of Douglas fir plywood and Lebanite (smooth-two-sides hardboard)

General office: Public Service Building, Portland, Oregon

Plant at: Lebanon, Oregon

Orton Endless Bed Surfacers

"Proved by Performance"



ORTON D-1, CABINET, ENDLESS BED SINGLE SURFACER
SIZES: 30x8-in., 36x8-in.

We offer ORTON equipment for

HEAVY DUTY SURFACING
CABINET OR FINISH SURFACING
GANG STRAIGHT EDGE RIPPING

(All with ORTON Traveling Bed Feed)

ORTON MACHINE COMPANY

Established 1886

Office and works:

390 FREMONT SAN FRANCISCO

MARKETING DIVISION

QUALITY CONTROL DIVISION

III. Proposals.

Suggestions for realizing Division objectives were that increased marketing or merchandising interest be injected into section meetings through assistance in securing papers in that field, and encouragement of group sessions as a part of section meeting programs. Another suggestion was that the next annual meeting include in a general session a paper dealing with the over-all merchandising field, and that the technical sessions include papers relating to merchandising problems within those fields. It was also recommended that the subject matter group be identified as the Merchandising Division.

IV. Organization.

Robert Pauley was designated as chairman, and George Olson vice chairman. A preliminary list of subcommittees by product area was established. They are: Hardboard, Joseph Allegretti; Particle Board, Robert Miller; Insulation Board; Plywood, John Ritchie; Lumber, Art Lahey and G. H. Smith; and Pulp, paper, and fiber boards.

Those who attended the meeting were: Joseph Allegretti, Masonite Corp.; Kenneth Chesley, Crossett Lbr. Co.; Ronald Gale, Ronald Gale Associates; Bernard Granum, Iron Range Resources & Rehab.; Joseph Hahn, Masonite Corp.; Clark Heritage, Consultant; J. S. Horn, American–Marietta; Louis Miller, American-Marietta; R. T. Miller, Weyerhaeuser Sales Co.; Frank Parrish, Heywood Wakefield Co.; John Ritchie, Douglas Fir Plywood Assoc.; Dave Wald, Ronald Gale Associates; Walter Walling, Georgia Pacific Co.; George Olson, Dow Chemical Co.

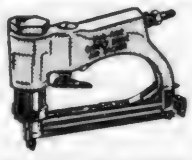
PACKAGING—Chairman, A. R. Tegge, Jr., Quartermaster Container Labs, Chicago, Ill.

Pending further deliberation on the place of packaging materials, containers, materials handling, and packaging sessions in the FPRS organization, arrangements were made to insert a report on these topics in the Annual Review, and to consider the possibility of including a packaging topic as a part of a selected technical session at the 1958 National Meeting in Madison.

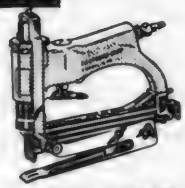
Potential appointees in various segments of the packaging industry have been contacted regarding possible committee service.

The Packaging Division was inactive at the 1957 National Meeting in Buffalo.

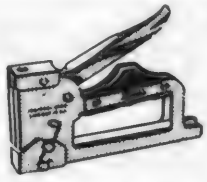
DUO-FAST Tackers and Staplers for the WOODWORKING INDUSTRY



DUO-FAST AIR TACKERS
Fast, effortless, efficient tackers for production work. 20 various models.

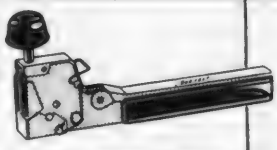


DUO-FAST AIR PLIER
Light, easily portable air-driven staplers. 8 various models.

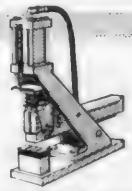


DUO-FAST GUN TACKERS
Great all-purpose hand tackers. 18 various models.

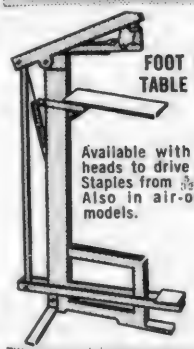
DUO-FAST HAMMER TACKERS
Fastest, manual tacking method. 6 various models.



DUO-FAST STRIKE TACKERS
Two-hand tackers for accurate placement of staples. 15 various models.



DUO-FAST BENCH MODELS
Air-operated staplers or tackers designed for bench-mounting. In single or multiple units. 11 various models.



FOOT POWER TABLE TACKER
Available with various heads to drive Duo-Fast Staples from 3/8" to 2".
Also in air-operated models.

At Your Service . . .

Duo-Fast offers a complete line of Staplers, Tackers, and Staples–a Free Service Guarantee –and 50 sales and service offices to help you with your fastening problems.

Write for complete Duo-Fast Story.

DUO-FAST FASTENER CORPORATION
3700 River Road FRANKLIN PARK, ILLINOIS

VENEER AND PLYWOOD DIVISION

WOOD COMPOSITION BOARD DIVISION

QUALITY CONTROL—Chairman, C. S. Latimer, Nickey Bros., Inc., Memphis, Tenn.

General plans of the Division were discussed. Mr. Charles A. Bicking, Carborundum Co., was asked to give his views on plans. He pointed out the emphasis on training by similar groups in other industries.

It was agreed to include a training session on quality control at the 1958 annual meeting. A suggestion was made to precede the training session by a speaker who could put across the advantages of proper quality control methods in woodworking. Aubrey Wylie and A. C. Barefoot are to plan the training session.

A report covering developments in quality control in woodworking will be submitted to the JOURNAL for publication in the Annual Review.

VENEER AND PLYWOOD—Chairman, H. O. Fleischer, U. S. Forest Products Lab., Madison, Wis.

The meeting was called to order by H. O. Fleischer. John Butler served as recorder. The minutes of the 1956 meeting were read. The chairman announced that Mr. John Butler, Hardwood Plywood Institute, Atlanta, Ga., has been proposed to the Board as chairman of the Division for the next year.

I. Research Facilities Surveyed.

Dr. Fred Dickinson and Dr. Wm. Nearn reported progress on a survey of research facilities and activities of interest to veneer and plywood manufacturers in the U. S. Copies of the reports prepared were distributed to those in attendance. Appreciation was expressed to Dr. Dickinson and Dr. Nearn for the excellent work done on behalf of the Division.

It was decided that the survey of research facilities should form the basis for the annual industry report of the Division for the current year. It was sugegsted that the new chairman of the Division ask Dr. Dickinson and Dr. Nearn to assume major responsibility in preparing this combined report.

II. 1957 National Meeting.

Discussion was held concerning the crowded technical program at the annual FPRS meetings, the channeling

There is a reason why BILT-WELL WOOD WORK REG. U. S. PAT. OFF. **is a leader!**

This is the modern plant where Bilt-Well Woodwork is "groomed" for its leading role in the building programs of today. Master craftsmen, research engineers and industrial designers pool their ideas in the scientific development of building products making it possible to produce a high standard of quality. The popularity of Bilt-Well Woodwork today stems from an enviable reputation built up in the past 92 years.

CARR, ADAMS & COLLIER COMPANY

Dubuque, Iowa

Manufacturers of the BILT-WELL Line of Outstanding Woodwork . . . BILT-WELL WINDOW UNITS—Awning, Double Hung, Casement, Basement, Storm and Screen, Gable Sash & Louvers . . . BILT-WELL CABINET UNITS—Kitchen, Wardrobe, Multi-Purpose, Corner China, Mobiltels . . . . BILT-WELL DOORS—Interior, Exterior, Combination, Screen.

WOOD DRYING DIVISION

WOOD FINISHING DIVISION

programs into those subjects which are of interest to the various subject matter committees, and possible neglect of other subjects. It was felt that more time was needed for full and thorough consideration of fundamental research papers. The opinion was expressed that difficulty was caused by concurrent meetings of various technical divisions, and it was felt that joint meetings to be sponsored by several divisions that have mutual interests were a good idea. The Division decided to request the Board to consider the need for establishing a "Division of Research".

A decision was taken to hold a general technical session on veneer and plywood at the 1958 annual meeting.

III. Attendance.

Those who attended the meeting were: Michael Papagiannis, Creek Government; Fred E. Dickinson, Calif. Forest Products Lab.; Russell K. Stensrud, Reichhold Chemicals, Inc.; W. T. Nearn, Penna. State University; Charles W. McMillin, University of Michigan; R. H. Bergstrom, L. F. Dettenborn W. W. Co.; Lee S. Jacobs, Chester B. Stem, Inc.; Albert R. Tegge, QM Container Lab; W. H. Reid, West Virginia University; R. A. Moore, N. Y. State College of Forestry; C. A. Hart, N. C. State College; H. O. Fleischer, U. S. Forest Products Lab.; John Butler, Hardwood Plywood Institute, Atlanta, Ga.

WOOD DRYING—Chairman, L. D. Espenas, Oregon Forest Products Lab., Corvallis, Ore.

The meeting was called to order by Fred E. Dickinson substituting for Chairman Espenas. Harold T. Rhodes served as Secretary. Mr. Espenas' resignation was accepted, and vice-chairman S. B. Preston was recommended as chairman. A suggestion was made that chairman of the Wood Drying Division serve for two or three years.

1. Report on the News–Digest

Mr. Rietz presented a report on the Division's News–Digest. Started in 1953, 51 issues have been prepared and distributed. The original objective of the NEWS–DIGEST was to encourage formation of dry-kiln clubs and

for Duty for Beauty

for the *Best* in laminates look to

Parkwood

HI-DEN (Parkwood trade name for densified wood) Made from carefully selected wood veneers, impregnated with phenolic resin, and compressed and cured under high pressure and temperature. Tough, dense, moisture- and oil-resistant, dimensionally stable, it is widely used in products ranging from industrial forming tools to architectural hardware, knife handles and conveyor systems.

GENUWOOD A high-pressure laminate which incorporates a layer of genuine precious-wood veneer, protected by a transparent Melamine overlay — bonded into cigarette-proof, alcohol-proof, acid- and scratch-resistant panels of surpassing beauty and finish. Much in demand by architects, decorators and designers for the highest quality furniture and interior applications.

PARKWOOD ALSO MAKES

PARKWOOD DECORATIVES

Beautiful, laminated plastic panels in a wide range of decorator colors, exclusive patterns and superb wood grain reproductions . . . for use in furniture, counter tops, walls, wainscoting and many other applications.

For samples and illustrative literature write

PARKWOOD LAMINATES, INCORPORATED

28 Water Street, Wakefield, Massachusetts

WOOD MACHINING DIVISION

WOOD PRESERVATION DIVISION

associations, and as much as possible keep them active. The general consensus of the membership was that the Digest was meeting this objective. Mr. Rietz reported that eight issues have been prepared on the subject of general seasoning, six on properties of wood related to drying, five on air drying, 30 on kiln drying, one on special drying methods, and one on predriers.

In his report. Mr. Rietz raised the question as to whether the Division is doing enough directly for members of the Society who are representative of management. He asked if the "status" report prepared yearly was sufficient. Believing that management was interested in the more technical aspects of drying processes and the equipment needed, the suggestion was made that perhaps the Division could be of more service by preparing abstracts of some of these papers for printing in the JOURNAL of the Society.

It was decided to try to present both technical and more general information in the NEWS–DIGEST. A suggestion was also made to form a new clinic of four members to abstract papers for the information of Society members.

II. Plans for the 1958 National Meeting.

The subject committee chairman was given responsibility for the technical session and theme for the 1958 National Meeting.

Subjects suggested were: high temperature drying kilnmotrol; electronic drying; speed of drying and quality of drying; quality drying with speed; air drying of northern red oak; stresses perpendicular to the grain; influence of surface roughness in drying rate; use and abuse of program control of kiln drying; air drying of hard and soft wood; accelerated yard drying; strength across grain drying of California redwood, strength of rag tissues as factor to differential shrinkage; high temperature drying on southern pine (panel discussion); degrade studies; ponderosa pine; and shrinkage on black oak.

III. Other Business.

It was reported that the bibliography will be out in 1958. The meeting favored that this service be included with the duties of the Abstracting Committee.

It was decided to put the survey of seasoning research in the annual report by divisions. It was also recommended to the chairman that a survey of research being done internationally be published in the JOURNAL.

WOOD FINISHING—Chairman, F. H. Thomas, Sherwin Williams Co., Chicago, Ill.

The meeting was opened with a statement of the responsibilities of the committee. These are: 1) the Annual Review Summary in the February issue of the FOREST PRODUCTS JOURNAL, which should cover all significant current developments of interest in the Wood Finishing Field, and 2) A technical program for the 1958 meeting.

A need was expressed for a list of FPRS members who are primarily interested in the Division activities so that they can constitute a mailing list for obtaining information and suggestions on these two subjects.

Vice chairman Lubeck reported that he has started to draw up a list of those who might be interested in the fields of education, research, furniture, manufacturing, paint manufacturing, wood associations, and so forth. He has already written to paint manufacturers asking them for information on research projects that might be subjects for papers at meetings. Names were given of many in industry that could be contacted.

I. National Meeting Subjects.

Suggestions for papers for future National Meetings were: airless spray; slow coating flat surfaces; steam spray; knife rubbing; stearated sandpaper; prefinished plywood; wood graining; telegraphing; exterior finishes; and west coast problems (specifically for the 1959 meeting).

WOOD PRESERVATION—Chairman, Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo.

Chairman Hatfield called the meeting to order and presented a brief history of the Division with its 1956 1957 activities and accomplishments.

I. Objectives.

A simplified set of bylaws were adopted by those present. The objectives set were: 1) to encourage and promote research in the preservation of forest products; 2) to encourage the preparation and presentation of technical papers and reports at Division meetings at both the regional and national levels, and to stimulate group discussions of subject matter relative to the preservation of forest products, 3) to present an annual report which will include a description of new test methods, materials, specifications, treating standards, preservative applications and uses, and new commercial uses of training chemicals, 4) To list new literature and to report on older literature that has a bearing on the activities in the field covered by the Division; 5) to seek and to propose methods for getting wood preservation technology translated into general practice.

II. Organization.

Dr. C. S. Walters, University of Illinois Agricultural Exp. Sta., was chosen 1958 Division Chairman, and Prof. A. H. Bishop, N. Y. State College of Forestry, Vice Chairman. The vice-chairman was given responsibility for the national meeting programs.

The members voted to have at least one technical session at the 1958 annual meeting in Madison, Wisconsin.

Approximately 50 members attended the business meeting.

Minutes of Meeting

(continued from page 45-A)

Be it resolved that the appreciation of the Society be extended to the management and the staff.

5. Recognizing the contributions that over 50 Paul Bunyan Smorgasbord sponsors have made to the social portion of our meeting,

Be it resolved that the Society extend its appreciation to the sponsoring companies and organizations.

6. Recognizing the contributions that the table-top exhibitors and field trips to plants have made to the success of this meeting,

Be it resolved that the Society extend its appreciation to the sponsoring companies and their organizations.

11. Report of Tellers Committee

The Tellers Committee, composed of Walton R. Smith, Carl de Zeeuw, J. F. Burrell, Wayne Murphey, A. D. Syska, N. C. Higgins, Walker Wellford, Arthur Schwalb, R. V. Reynolds, T. P. Wier, Jr., A. K. Kemp, and Chairman William Finley, counted the ballots and reported the following elected: President Elect, W. Jeter Eason; Vice-President, E. S. Harrar, Northwest Regional Board Member, T. S. Veazey, Jr.; Northeast Regional Board Member, D. K. Sanuders, and the 1957 National Nominating Committee: A. L. Mottet, N. V. Poletika, R. C. Rietz, and R. W. Wellwood.

12. Introduction of New Officers

Outgoing President Ralph H. Bescher, having served for six years on the Executive Board, acknowledged and extended the gratitude of the Board to these outgoing Board Members: Immediate Past President, Moss B. Christian, who served seven years; Past Northwest Regional Board Member, John D. Ritchie, who served three years; Past Northeast Regional Board Member, Charles R. Lockard, who served one year.

He introduced the incoming members T. S. Veazey Jr., and D. K. Saunders. Mr. Bescher then introduced the new President-Elect, W. Jeter Eason, the new Vice-President, E. S. Harrar, and presented the President's gavel to his successor Dr. F. H. Kaufert.

13. Adjournment

President F. H. Kaufert declared the meeting adjourned at 5:00 P.M.

Section Officers Advisory Meeting

(continued from page 47-A)

group in its discussion of a uniform set of By-Laws for all Sections. The Executive Secretary was instructed by the Executive Board to send copies of the model By-Laws to each Section. A complete chart indicating the basic points of difference in all existing By-Laws of the 14 Sections as prepared by the chairman of the Constitution and By-Laws Committee is also to be sent. The intent of the Board is to work toward adoption of uniform By-Laws by all Sections at the earliest date. It was hoped that the Board would receive comments of the Sections no later than October 15.

8. Formal commendation was presented by Mr. Kluender on behalf of the Section officers for the excellent manner in which the 1957 National Meeting was arranged and administered.

The meeting was officially adjourned.

Complete Service On Wood Preservatives!

TECHNICAL COUNSEL
A full staff of specialists with years of experience and complete laboratory facilities, ready to assist in every way.

ENGINEERING SERVICE
An experienced engineering department to help in planning, designing and installing new pressure-treating plants; modernizing old plants; selecting equipment to meet your specific needs.

WOODTOX Penta Preservative and Water Repellent
A clear, clean, non-staining treatment combining advantages of Penta plus resistance against swelling, warping, shrinking and other moisture damage. Meets NWMA and Western Pine Assoc. preservative standards.

PENTAchlorophenol WOOD PRESERVATIVES
Most satisfactory and permanent of all wood preservatives against decay, fungi, termites and other wood boring insects.

NOXTANE SAP STAIN CONTROL
Most effective, safe and economical treatment made for protection against sap stain fungi. Leaves wood bright and clear. Quick solubility, dustless, non-irritating. Won't damage metal equipment.

EQUIPMENT
Exclusive national sales agents for Efurd Machine & Welding Company, builders of Hurricane Debarkers, Peelers, Framers, Incisors, Trams, etc.

Whatever your problem in the protection and preservation of forest products, this is where you can always get the *right answers quick!* Write or phone.

WOOD TREATING

WOOD TREATING CHEMICALS CO.
5137 Southwest Avenue St. Louis 10, Missouri

Meet FPRS 100 Company Supporting Members

ALABAMA
International Paper Co., Mobile
ARKANSAS
The Crossett Co., Crossett
Dierks Forests, Inc., Hot Springs
Southern Lumber Co., Warren
CALIFORNIA
California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
High Sierra Pine Mills, Inc., Oroville
Ivory Pine Co., Dinuba
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
E. K. Wood Lumber Co., San Francisco
IDAHO
Boise Payette Lumber Co., Boise
Ohio Match Co., Coeur d'Alene
ILLINOIS
The Dean Company, Chicago
General Electric, Ill. Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin-Williams Co., Chicago
INDIANA
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
KENTUCKY
Deluxe Saw & Tool Company, Louisville
MAINE
Moose Head Mfg. Co., Monson
MARYLAND
J. I. Wells, Salisbury
MASSACHUSETTS
Atlas Plywood Corp., Boston
Draper Corp., Hopedale
Heywood-Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee
MICHIGAN
Armstrong Machine Works, Three Rivers
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven
MINNESOTA
Mereen-Johnson Machine Co., Minneapolis
Minnesota Mining and Mfg. Co., St. Paul
Rilco Laminated Products, Inc., St. Paul
Wabash Screen Door Co., Minneapolis
MISSISSIPPI
Richton Tie and Timber Co., Richton
MISSOURI
Monsanto Chemical Co., St. Louis
MONTANA
Intermountain Lumber Co., Missoula
NEVADA
Vaughn Millwork Co., Reno
NEW JERSEY
National Adhesives, Plainfield
Western Electric Co., Kearny
NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
The New Jersey Industries, Inc., New York
Oval Wood Dish Corp., Tupper Lake
Pierce & Stevens Chemical Corp., Buffalo
Reichhold Chemicals, Inc., White Plains
United States Plywood Corp., Brewster
The Upson Co., Lockport
OHIO
American Machine & Foundry Co., Shelby
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati
OREGON
Brooks-Scanlon, Inc., Bend
Cascades Plywood Corporation, Lebanon
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland
PENNSYLVANIA
Kennametal, Inc., Latrobe
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer
SOUTH CAROLINA
Lightsey Brothers, Miley
Poinsett Lumber & Mfg. Co., Pickens
TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis
TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Love Wood Products of Texas, Diboll
Southern Pine Lumber Co., Diboll
VERMONT
Beecher Falls Mfg. Corp., Beecher Falls
WASHINGTON
American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
International Paper Co., Long-Bell Division, Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma
WISCONSIN
Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh
ALASKA
Ketchikan Spruce Mills, Ketchikan
CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co., Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

HARSHAW WOOD PRESERVATIVE INGREDIENTS

COPPER NAPHTHENATE LIQUID 8%

Description	Clear green liquid	Viscosity	13.0 poises
Copper content	8%	Specific Gravity	1.02
Solid copper naphthenate content	72%	Pounds per gallon . . .	8.5
Solvent content	28%	Gallons per pound . . .	0.118

Conforms to National Bureau of Standards' Commercial Standard CS 152-48 (Sept. 25, 1948) "Copper Naphthenate Wood Preservative" concentrated type.

If you need Copper Naphthenate Liquid of any special concentration, Harshaw can quickly manufacture it for you. For prompt service send your order to the nearest Harshaw branch sales office.

THE HARSHAW CHEMICAL CO.
1945 East 97th Street, Cleveland 6, Ohio
BRANCHES IN PRINCIPAL CITIES

Cleveland • Chicago • Cincinnati • Detroit • Houston • Los Angeles • New York • Philadelphia • Pittsburgh

Directory, FPRS Officers and Committees

F. H. KAUFERT

W. J. EASON

E. S. HARRAR

R. H. BESCHER

W. L. IRWIN

W. R. WARNER

D. K. SAUNDERS

R. L. HILLER

T. S. VEAZEY, JR.

R. H. BERRY

With a membership of over 3500 persons as this Yearbook issue goes to press, the national work of FPRS is administered by elected Executive Board comprised of four officers and six regional board members. The sectional work is governed by 105 officers and trustees. The various administrative and subject matter committees add another 225 names to the work of the Society.

Executive Officers

President—Frank H. Kaufert, Institute of Agriculture, School of Forestry, University of Minnesota, St. Paul 1, Minn.

President-Elect—W. Jeter Eason, Vice Pres., Nickey Bros., Inc., 2700 Summer Ave., Memphis 12, Tenn.

Vice-President—E. S. Harrar, School of Forestry, Duke University, Durham, N. C.

Past-President—Ralph H. Bescher, Ass't. to Vice Pres. & Gen. Mgr., Wood Preserving Division, Koppers Company, Inc., Pittsburgh 19, Pa.

Executive Secretary—Frank J. Rovsek, Box 2010, University Station, Madison 5, Wis.

Regional Board Members

Southeast Region—William L. Irwin, Poinsett Lbr. & Mfg. Co., Pickens, S. C.

Northeast Region—Donald K. Saunders, Saunders Brothers, Westbrook, Me.

South-Central Region—W. R. Warner, Southern Lbr. Co., Warren, Ark.

North-Central Region—Robert L. Hiller, Route 1, Hartland, Wis.

Northwest Region—T. S. Veazey, Jr., The Anaconda Company, 10 E. Quartz Street, Butte, Mont.

Southwest Region—Raymond Berry, V.P., Scott Lumber Co., Inc., Burney, Calif.

Section Officers

CAROLINAS–CHESAPEAKE

Chairman—John B. Veach, Jr., Hardwood Corporation of America, Box 1091, Asheville, N. C.

Vice-Chairman—James S. Bethel, N. C. State College, Raleigh, N. C.

Secretary-Treasurer—Michael A. Taras, Southeastern Forest Exp. Sta., School of Forestry, N. C. State College, Raleigh, N. C.

Trustee—P. F. DeSaix, Box 1574, High Point, N. C.

Trustee—John B. Hayward, Perkins Glue Company, 500 Sunset Avenue, High Point, N. C.

EASTERN CANADIAN

Chairman—E. A. Thompson, Canada Creosoting Co., 1400 Metcalfe St., Montreal 2, Que., Canada

1st Vice-Chairman—Georges Roy, V.P., Plywood Associates, Inc., 63 Ste. Rose Blvd., P. O. Box 90, Ste. Rose (Laval) P. Q., Canada

2nd Vice-Chairman—G. S. Billington, Moore Dry Kiln Co., Ltd., P. O. Box 707, Brampton, Ont., Canada

Secretary—R. F. DeGrace, Canadian Institute of Timber Construction, 140 Wellington St., Ottawa, Ont., Canada

Treasurer—Peter M. Morley, Canadian International Paper Co., Gatineau, Que., Canada

Past Chairman—Kenneth O. Roos, Gen. Mgr., Booth Lumber Limited, Tee Lake, Que., Canada

Trustee—Clayton Allgeier, Dom. Electrohome Ind. Ltd., Kitchener, Ont., Canada

Trustee—G. W. Hossack, 1801 Le Ber St., Montreal, Que., Canada

Trustee—A. S. Michell, University of Toronto, Toronto, Ont., Canada

Trustee—J. Clive Reade, Canadian Woodworker, 1450 Don Mills Road, Don Mills, Ont., Canada

Trustee—H. C. Knight, Secy.-Treas., The Knight Mfg. & Lbr. Co., Edwin Street, Meaford, Ont., Canada

Trustee—Maurice Gerin, Mgr., % The Quebec Lumber Mfrs. Assn., P. O. Box 86 U. T., Quebec 4, P. Q., Canada

Trustee—Dr. J. Risi, Faculty of Science, Laval University, Quebec, Que., Canada

FLORIDA–GEORGIA–ALABAMA

Chairman—Rufus H. Page, Georgia Forestry Center, P.O. Box 1183, Macon, Ga.

Vice-Chairman—Windell W. Vickery, 1706 28th St., Sheffield, Ala.

Secretary-Treasurer—Ralph Peter, Athens-Macon Research Center, School of Forestry, University of Georgia, Athens, Ga.

Trustee—Bruce Anderson, 3630 Peachtree Road, Atlanta, N.E., Ga.

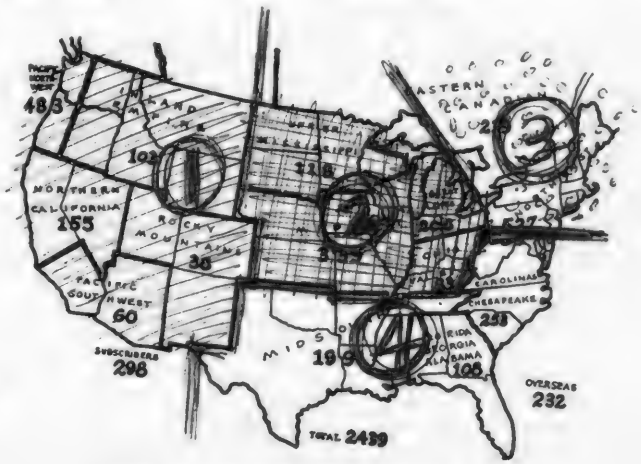
Trustee—Carl Brice, Brice Lbr. Co., Archer, Fla.

Trustee—Gus Jacobson, Soderhamn Machine Mfg. Co., Talladega, Ala.

Trustee—D. W. McConnell, Pres., Coosa Charcoal Co., 2809 Central Ave., Birmingham 9, Ala.

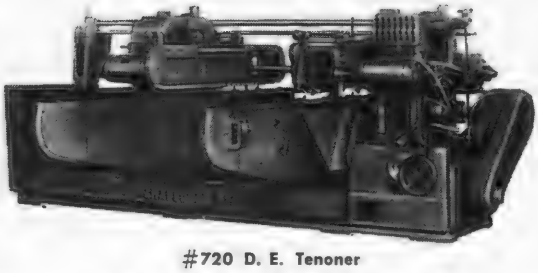
Trustee—Raymond L. Osborne, 2174 Brook Valley Lane N.E., Atlanta 5, Ga.

Trustee—Ben M. Turner, Ass't. Secy. & Treas., Cordele Sash, Door & Lumber Co., Cordele, Ga.



FPRS' 14 sections and their membership totals.

#520 D. E. Tenoner



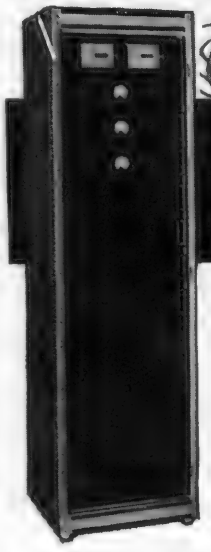
#720 D. E. Tenoner

CHALLONER

"SINCE 1866"

CHALLONER MANUFACTURING CORP.
AND
CKL MACHINERY CO.
OSHKOSH, WIS.

A New Concept in Continuous Moisture Control



LAUCKS Sentry® CUSTOM
CONTINUOUS MOISTURE DETECTOR

The new Custom introduces an outstandi advance in SENTRY systems for measuri and recording moisture content of movi veneer, lumber, paper and various unrelated non-cellulose materials.

The Custom accents unitized constructi with primary circuits in lightweight "plug- type" drawers. The moisture range has be expanded from zero to fibre saturation. Mo- ture classification (marking) of stock is go- erned by a single control.

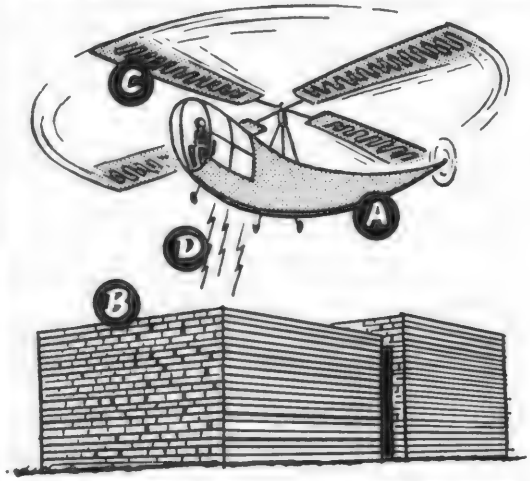
Designed primarily for larger installatior Custom models are also ideal for overseas us Through an exchange of drawers the enti e system may be serviced or expanded wit- out delay.

SENTRIES range from single level marking units to multi-lev marking, recording and counting systems, and are priced from $3,95 You are cordially invited to write for detailed information.

LAUCKS LABORATORIES, INC.
1201 Poplar Place — Seattle 44, Washington
A leader in wood technology for 49 years

SOMEDAY...

you may be able to dry lumber in a different way



Helicopter (A) hovers over stacks of green lumber (B). Heating coils (C) in propeller blades warm air as it is blown over stacks. Radio waves (D) measure moisture content so that pilot knows when to move to next stack.

History is strewn with the wreckage of machines and methods made obsolete by technological development. Perhaps science will discover a new way to dry lumber.

But contrary to the claims of some, that day has not yet come. The best lumber drying system is still the conventional one of blowing air over the lumber surface at 300 f.p.m. or more at temperatures and humidities recommended by reputable dry kiln engineers.

The WEL-DRI Kiln will provide accurately controlled temperatures and humidities for any schedules up to 230° F. It incorporates every element of modern kiln design and construction. Before you buy, ask for a quotation on a WEL-DRI Kiln engineered to your exact needs.

THE
WEL-DRI
COMPANY
730 S. Third St., Box 2834
Memphis 2, Tennessee

B. VEACH, JR.

R. H. PAGE

FRED ATKINSON

H. B. McKEAN

D. M. FISHER, JR.

J. J. ALLEGRETTI

GREAT LAKES

Chairman—Fred Atkinson, 749 Fourth Street, N.W., Grand Rapids, Mich.

1st Vice-Chairman—S. W. Tamminga, V.P., Hekman Furniture Co., 1400 Buchanan Ave., S.W., Grand Rapids 2, Mich.

2nd Vice-Chairman—E. Brooks Applegate, Travis–Applegate Co., 714 Building & Loan Building, Grand Rapids 2, Mich.

Secretary—Norman C. Franz, 2970 Easy St., Ann Arbor, Mich.

Treasurer—James C. Witty, Herman Miller Furniture Co., Zeeland, Mich.

Trustee—Gardner G. Garlick, Protection Products Mfg. Co., Box 747, Kalamazoo 99, Mich.

Trustee—Wayne F. Hutchins, Research Dept., American Seating Co., Grand Rapids, Mich.

Trustee—Alexis J. Panshin, Head, Dept. of Forest Products, Michigan State University, B–4 South Campus, East Lansing, Mich.

Trustee—S. B. Preston, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

INLAND EMPIRE

Chairman—Herbert B. McKean, Potlatch Forests, Inc., Lewiston, Ida.

Vice-Chairman—Ross McNett, President, Biles–Coleman Lbr. Co., Omak, Wash.

Secretary-Treasurer—Irvin Wentworth, Northwest Timber Co., Gibbs, Ida.

Past Chairman—T. S. Veazey, Jr., The Anaconda Co., 10 E. Quartz St., Butte, Mont.

Trustee—C. M. Kreider, Ass't. Mgr., Brooks–Scanlon, Inc., Bend, Ore.

Trustee—Lawrence E. O'Neil, Forest Products Co., Kalispell, Mont.

Trustee—Owen C. Sawyer, Peshastin Lbr. & Box Co., Peshastin, Wash.

Trustee—J. H. Leuthold, S. 2921 High Drive, Spokane, Wash.

MID-SOUTH

Chairman—D. M. Fisher, Jr., Southern Lbr. Co., Warren, Ark.

Vice-Chairman—V. W. Cothern, Southern Pine Ass'n., 520 Canal Bldg., New Orleans 4, La.

Secretary-Treasurer—W. L. Lear, Crossett Lbr. Co., Crossett, Ark.

Trustee—John Lehman, TVA Forestry Bldg., Norris, Tenn.

Trustee—Wm. A. Lyons, The Long–Bell Lbr. Co., P.O. Box 286, Oklahoma City, Okla.

Trustee—E. J. Ogran, P.O. Box 123, Hope, Ark.

Trustee—H. E. Bovay, Jr., 5009 Caroline St., Houston, Texas

Trustee—Mark M. Lehrbas, Southern Forest Exp. Station, 707 Lowich Bldg., 2[illegible]6 St. Charles Ave., New Orleans, La.

MIDWEST

Chairman—J. J. Allegretti, Masonite Corp., 111 W. Washington St., Chicago 2, Ill.

Vice-Chairman—Dwight W. Bensend, Dept. of Forestry, Iowa State College, Ames, Iowa

Secretary—Robert Archambeault, 1306 Schriber, Joliet, Ill.

Treasurer—William A. Kluender, Resources Dev. Dept., C. & N.W. Railway System, 400 W. Madison St., Chicago 6, Ill.

Trustee—L. J. Fitzpatrick, J. J. Fitzpatrick Lbr. Co., 5001 University Ave., Madison 5, Wis.

Trustee—Harvey J. Gill, Jr., Carr, Adams & Colllier Co., Dubuque, Iowa

Trustee—Jack Koellisch, % Wood & Wood Products, 139 N. Clark St., Chicago, Ill.

Trustee—Wayne C. Lewis, U. S. Forest Products Laboratory, Madison, Wis.

Trustee—William Mitchell, U. S. Forest Products Laboratory, N. Walnut St., Madison 5, Wis.

Trustee—Charles S. Walters, Illinois Agric. Exp. Station, 219 Mumford Hall, Urbana, Ill.

NORTHEAST

Chairman—Eric A. Anderson, State University of New York College of Forestry, Syracuse 10, N.Y.

Vice-Chairman—J. Allan Hauter, Allan Products Co., Oradell, N. J.

Secretary-Treasurer—Ben A. Jayne, Yale University, School of Forestry, New Haven 11, Conn.

Trustee—Chester L. Babcock, Babcock Machinery Co., Inc., 1475 Broadway, New York 18, N. Y.

Trustee—Jack E. D. Batson, Kittinger Company, Buffalo, N. Y.

E. A. ANDERSON

N. T. SHELTON

Trustee—Newell A. Norton, Department of Forestry, Pennsylvania State University, University Park, Pa.

Trustee—Donald Pierce, Maine Skewer & Dowel Corp., Farmington, Me.

Trustee—Charles R. Lockard, Northeast Forest Experiment Sta., 102 Motors Avenue, Upper Darby, Pa.

Trustee—Paul H. Graham, Box 105, Newfane, Vt.

Trustee—William J. Delmhorst, Delmhorst Instrument Co., 607 Cedar St., Boonton, N. J.

Trustee—Frank T. Patrish, Heywood–Wakefield Co., Central St., Gardner, Mass.

Committees

Publications Coordinator—R. F. West, Forestry Dept., Rutgers Univ., New Brunswick, N. J.

Chairman, Education—W. T. Nearn, Pennsylvania State Univ., University Park, Pa.

Chairman Publicity—A. G. Battaglia, National Starch Products Co., Plainfield, N. J.

NORTHERN CALIFORNIA

Chairman—N. T. Shelton, The Diamond Match Co., P.O. Box 1037, Chico, Calif.

Vice-Chairman—Robert M. Kuhn, 264 Gerry Court, Walnut Creek, Calif.

Secretary-Treasurer—Peter Field, Ivory Pine Co., Box 116, Dinuba, Calif.

Past-Chairman—Homer N. Stephenson, Sacramento Box & Lbr. Co., P.O. Box 1282, Sacramento 6, Calif.

Trustee—Fred E. Dickinson, University of California, Forest Products Laboratory, 1301 South 46th St., Richmond 4, Calif.

Trustee—Byrne Manson, Simpson Redwood Co., Arcata, Calif.

OHIO VALLEY

Chairman—Paul Fenn, Tell City Chair Co., 417 Seventh St., Tell City, Ind.

Vice-Chairman—Sterling Durst, Gamble Bros., 4600 Almond Ave., Louisville, Ky.

Secretary-Treasurer—John R. Young, Oliver Machinery Co., Paoli Star Route, Altawood, New Albany, Ind.

Trustee—Jerome F. Habig, Box 47, Jasper, Ind.

Trustee—Henry A. Espel, Baldwin Piano Co., 1801 Gilbert Ave., Cincinnati 2, Ohio.

PACIFIC NORTHWEST

Chairman—Robert W. Wellwood, Faculty of Forestry, University of British Columbia, Vancouver 8, B. C., Canada

Vice-Chairman—John H. Syme, Edward Hines Lbr. Co., Hood River, Ore.

Secretary—P. L. Northcott, U. S. Forest Products Laboratory of Canada, Univ. of Br. Columbia Campus, Vancouver 8, Br. Col., Canada

Treasurer—Wm. R. Francis, 123 Birch St., Shelton, Wash.

Past-Chairman—J. R. Stillinger, Cascades Plywood Corp., Lebanon, Ore.

Trustee—Alexander M. Fisken, Weyerhaeuser Timber Co., Tacoma, Wash.

Trustee—G. E. Tower, Forest Fiber Products Co., Box 68, Forest Grove, Ore.

PACIFIC SOUTHWEST

Chairman—Paul Yankauskas, 4508 Blackthorne Ave., Long Beach 8, Calif.

Vice-Chairman—A. J. Long, Monsanto Chemical Co., 6670 E. Flotilla St., Los Angeles 22, Calif.

Secretary-Treasurer—W. E. Ripley, Jr., Stauffer Chemical Co., Molded Products Div., 3211-15 E. 26th St., Los Angeles 23, Calif.

Past-Chairman—A. N. Swenson, Jr., 13026 Burton St., No. Hollywood, Calif.

Trustee—Melvin R. Roberts, Cal-Wood Mfg. Co., 1541 W. 132nd St., Gardena, Calif.

Trustee—Robert Blumenthal, Furniture

Guild of Calif., 1601 E. 15th St., Los Angeles 21, Calif.

ROCKY MOUNTAIN

Chairman—T. W. Schomburg, 1002 Midland Savings Bldg., Denver 2, Colo.

Vice-Chairman—W. R. Fritze, 5601 Fox St., Denver 16, Colo.

Secretary-Treasurer—Lincoln A. Mueller, Rocky Mt. Forest & Range Exp. Sta., Forest Bld., Fort Collins, Colo.

Trustee—H. E. Troxell, Jr., School of Forestry, Colorado State Univ., Fort Collins, Colo.

Trustee—J. Stanley Weidman, Weidman Lumber Co., Box 720, Durango, Colo.

UPPER MISSISSIPPI VALLEY

Chairman—Henry Crandall, Mosinee Paper Mills Co., Mosinee, Wis.

Vice-Chairman—Walter B. Wallin, School of Forestry, University of Minnesota, St. Paul 1, Minn.

Secretary—Paul H. Lane, Lake States Forest Exp. Sta., Northern Lakes Forest Res. Cen., Court House Annex, Wausau, Wis.

Treasurer—Wayne Lewis Meek, % Minnesota & Ontario Paper Company, Research Div., International Falls, Minn.

Past-Chairman—Howard Olson, Timber Products Chemical Co., 1509 Foshay Tower, Minneapolis 2, Minn.

Committees

EXECUTIVE OFFICE BUILDING FUND

Chairman—R. H. Berry, Scott Lumber Co., Burney, Calif.

W. R. Warner, Southern Lumber Co., Warren, Ark.

R. W. WELLWOOD

HENRY CRANDALL

W. L. Irwin, Poinsett Lbr. & Mfg. Co., Pickens, S. C.

CONSTITUTION & BY-LAWS

Chairman—R. H. Berry, Scott Lumber Co., Burney, Calif.

BUDGET & FINANCE

Chairman—W. J. Eason, Vice President, Nickey Brothers, Inc., Memphis 12, Tenn.

D. K. Saunders, Saunders Bros., Westbrook, Me.

W. L. Irwin, Poinsett Lbr. & Mfg. Co., Pickens, S. C.

EXECUTIVE OFFICE BUILDING CONSTRUCTION COMMITTEE

Chairman—W. J. Eason, Nickey Bros., Inc., 2700 Summer Ave., Memphis 12, Tenn.

Supervising Architect—Otto Heyer, U. S. Forest Products Laboratory, Madison, Wis.

F. J. Rovsek, Forest Products Research Society, Madison, Wis.

1958 NATIONAL MEETING

General Chairman—Robert L. Hiller, Route 1, Hartland, Wis.

Technical Program Chairman—W. Jeter Eason, Nickey Bros., Inc., 2700 Summer Ave., Memphis 12, Tenn.

Local Arrangements Chairman—J. J. Allegretti, Masonite Corp., 111 W. Washington St., Chicago, Ill.

Finance & Registration Chairman—W. A. Kluender, C. & N. W. Railway System, 400 W. Madison St., Chicago, Ill.

Charles R. Batten, 275 E. 4th St., St. Paul 1, Minn.

Publicity Chairman—G. G. Garlick, Director of Research, Protection Products Mfg. Co., Box 747, Kalamazoo 99, Mich.

Social Arrangements Chairman—T. Walter Noble, Tech. Director, Dexar Plastic Corp., Middleton, Wis.

L. J. Fitzpatrick, Pres., J. J. Fitzpatrick Lbr. Co., 5001 University Ave., Madison 5, Wis.

U. S. Forest Products Laboratory Tour Chairman—John C. Killebrew, U. S. Forest Products Laboratory, Madison 5, Wis.

Ladies' Program—Mrs. R. J. Simeone, 2810 Regent St., Madison 5, Wis.

CO-ORDINATOR, FPRS DIVISION

E. S. Harrar, School of Forestry, Duke University, Durham, N. C.

PUBLICATIONS

Chairman—E. G. Locke, Chief, Div. of Wood Chemistry, U. S. Forest Products Laboratory, Madison 5, Wis.

South-Central Region—E. A. Behr, Chapman Chemical Co., Mallory Sta., Box 3138, Memphis, Tenn.

Southeast Region—Walton R. Smith, Southeastern Forest Experiment Station, Asheville, N. C.

CURVED PLYWOOD?

Made to specification

High-Frequency bonding on low cost forms

Tell us your problem — we'll solve it to your specifications. We manufacture unusual plywood shapes for applications ranging from church pews to water skis . . . table legs to torpedo cradles. Our high-frequency presses mass-produce curved parts fast and at lower cost than other methods, and with greater stability. We have over 200 stock dies available for stock shapes. Write, wire or phone RI 2-2474 for quotations and complete engineering service.

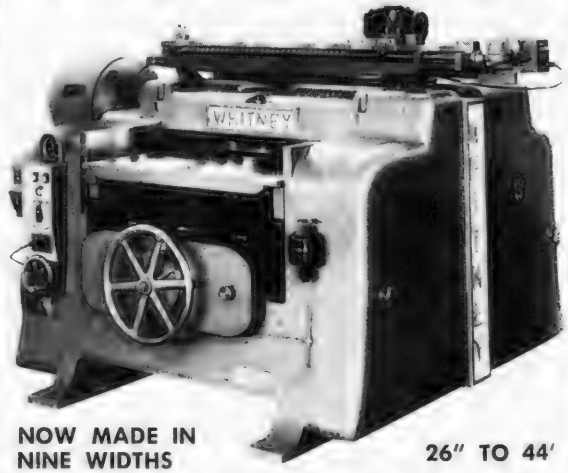
PLY-CURVES INC.

1615 Monroe Avenue, N.W., Grand Rapids 5, Michigan

WHITNEY S-290

QUALITY PRODUCTION

SINGLE SURFACER



NOW MADE IN NINE WIDTHS

26" TO 44'

Will dress stock 8" thick and as short as 14' when not butted or 3" butted.

Four knife round cutterhead. Feeds to 105 feet per minute.

WRITE TODAY FOR FULL INFORMATION, SPECIFICATIONS AND PRICES

BAXTER D. WHITNEY & SON, INC.

WINCHENDON, MASS. GREENSBORO, N. C

E. G. LOCKE

N. A. NORTON

M. B. CHRISTIAN

A. S. GREGORY

Southwest Region—R. A. Cockrell, School of Forestry, Univ. of California, Berkeley, Calif.

Northeast Region—E. A. Anderson, New York State College of Forestry, Syracuse 10, N. Y.

North Central Region—S. B. Preston, School of Natural Resources, Univ. of Michigan, Ann Arbor, Mich.

Northwest Region—R. N. Hammond, 1305 E. 43rd St., Seattle 5, Wash.

Members-At-Large

R. W. Wellwood, Faculty of Forestry, Univ. of Br. Columbia, Vancouver 8, B. C., Canada

I. H. Isenberg, Institute of Paper Chemistry, Box 498, Appleton, Wis.

H. B. McKean, Potlatch Forests, Inc., Lewiston, Ida.

F. F. Wangaard, Yale School of Forestry, New Haven, Conn.

EMPLOYMENT

Chairman—N. A. Norton, School of Forestry, Pennsylvania State University, University Park, Pa.

E. A. Behr, Chapman Chemical Co., Mallory Sta., Box 3158, Memphis, Tenn.

Roy M. Carter, North Carolina State College, Raleigh, N. C.

Eric W. Stark, Department of Forestry, Purdue University, Lafayete, Ind.

R. W. Pettersen, Route 6, Box 810, Tacoma, Wash.

H. H. Smith, P. O. Box 245, Berkeley 1, Calif.

1958 NATIONAL NOMINATING

Chairman—M. B. Christian, Dir. of Research, Chicago Mill & Lbr. Co., Tallulah, La.

L. J. Carr, L. J. Carr & Co., P. O. Box 1282, Sacramento, Calif.

A. L. Mottet, International Paper Co., Long-Bell Div., P. O. Box 1079, Longview, Wash.

N. V. Poletika, Union Lumber Co., Fort Bragg, Calif.

R. C. Rietz, U. S. Forest Products Laboratory, Madison 5, Wis.

Dr. R. W. Wellwood, Faculty of Forestry, Univ. of Br. Columbia, Vancouver 8, B. C., Canada

National Membership Committee

Chairman—T. S. Veazey, Jr., The Anaconda Co., 10 E. Quartz St., Butte, Mont.

SECTION MEMBERSHIP CHAIRMEN

CAROLINAS–CHESAPEAKE

T. D. Johnson, Mgr., Reichhold Chemicals, Inc., Box 3715, Charlotte 3, N. C.

EASTERN CANADIAN

G. S. Billington, Moore Dry Kiln Co., Ltd., P. O. Box 707, Brampton, Ont., Canada

FLORIDA–GEORGIA–ALABAMA

Ralph Peter, Athens–Macon Research Center, School of Forestry, University of Georgia, Athens, Ga.

State Chairmen

William B. Black, Gulf States Paper Corp., Tuscaloosa, Ala.

Ben Turner, Cordele Sash & Door Co., Cordele, Ga.

Amos Kelley, Wood Treating Chemicals Co., 716 S. Orleans Ave., Tampa 6, Fla.

GREAT LAKES

E. Brooks Applegate, Travis–Applegate Co., 714 Building & Loan Building, Grand Rapids 2, Mich.

INLAND EMPIRE

Charles Kreider, Brooks–Scanlon, Inc., Bend, Ore.

MID-SOUTH

John E. Fox, W. S. Fox & Sons, P. O. Box 158, Pine Bluff, Ark.

MIDWEST

Hugh D. Welch, Jr., Iowa Missouri Walnut Co., Second and Atchison Sts., St. Joseph, Mo.

NORTHEAST

Robert Gill, Peter Cooper Corp., Gowanda, N. Y.

NORTHERN CALIFORNIA

Victor H. Roth, Triangle Lumber Co., 610 Sixteenth St., Oakland 12, Calif.

OHIO VALLEY

Jerome F. Habig, Box 47, Jasper, Ind.

PACIFIC NORTHWEST

Earl T. McCarthy, 4315 E. 38th St., Seattle 5, Wash.

UPPER MISSISSIPPI VALLEY

Walter B. Wallin, School of Forestry, University of Minnesota, St. Paul 1, Minn.

FPRS DIVISIONS

CHEMICAL UTILIZATION

Chairman—A. S. Gregory, Mgr., Central Research Dept., Weyerhaeuser Timber Co., Longview, Wash.

Vice-Chairman—Irwin Pearl, Institute of Paper Chemistry, Appleton, Wis.

Secretary—F. G. Perry, Jr., A. D. Little, Inc., 30 Memorial Dr., Cambridge 42, Mass.

GLUES AND GLUING

Chairman—R. F. Blomquist, U. S. Forest Products Laboratory, Madison 5, Wis.

Vice-Chairman—Ben S. Bryant, College of Forestry, Univ. of Washington, Seattle 5, Wash.

Sub-Committees

Adhesives—R. F. Blomquist, U. S. Forest Products Laboratory, Madison 5, Wis.

Techniques & Glued Products—C. F. MacLagan, The Borden Co., Bainbridge, N. Y.

NOW—CHECK ACCURACY WHILE YOU CHECK MOISTURE!

New Electronic Moisture Registers have first "built-in standard" in a 3-second, portable moisture tester.

NOW DIAL ACCURACY IS ASSURED, even under the extremes of production-line use. With *self-checking standard*, Moisture Register's new Model 5's are checked and adjusted for calibration accuracy right on the job—by any untrained operator. He simply fits electrode to standard. Then with new trimmer he sets dial for perfect alignment. Gives calibration adjustment *in the field*. You get practical accuracy down to 0% ... 3-second spot tests for moisture wherever your product may be. Portable, light weight, battery operated, new rugged construction with miniature tube. Factory-set to your needs.

For faster testing of—

- Hard and soft woods
- Peeled log to finished product
- Lumber, cabinets, furniture, veneer, plywood

SEND FOR NEW TECHNICAL DATA and information on 2-week free trial.

ELECTRONIC MOISTURE REGISTER Instruments

Moisture Register Company, Dept. FJ
P. O. Box 910, Alhambra, California
Please send data on new Model 5's.

We are testing _____

in moisture range from _____% to _____%

Firm _____

By _____ Title _____

Address _____

City _____ State _____

R. F. BLOMQUIST

J. S. BETHEL

Test Methods—John Butler, Hardwood Plywood Institute, 1012 Crescent Ave., N.E., Atlanta, Ga.

Equipment—R. W. Williams, American–Marietta Co., 3400–13th Ave., S.W., Seattle 4, Wash.

Current Research—J. S. Bethel, North Carolina State College, Raleigh, N. C.

Bibliography—Ben S. Bryant, College of Forestry, Univ. of Washington, Seattle 5, Wash.

1958 Technical Session—Ben S. Bryant, College of Forestry, Univ. of Washington, Seattle 5, Wash.

Annual Review—R. F. Blomquist, U. S. Forest Products Laboratory, Madison 5, Wis.

Farrini

INDUSTRY–EDUCATION

Chairman—James S. Bethel, Director, Wood Products Laboratory, School of Forestry, N. C. State College, Raleigh, N. C.

Vice-Chairman—N. V. Poletika, Union Lumber Co., Fort Bragg, Calif.

Herbert B. McKean, Potlatch Forests, Inc., Lewiston, Idaho

Herbert O. Fleischer, U. S. Forest Products Laboratory, Madison 5, Wis.

Frederick F. Wangaard, School of Forestry, Yale University, New Haven 11, Conn.

Harold C. Moser, Gamble Brothers, Inc., 1601 Almond Ave., Louisville 9, Ky.

Clarence F. Van Epps, Stromberg Carlson Co., 100 Carlson Rd., Rochester, N. Y.

Everett Ellis, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

H. N. Stephenson, Sacramento Box & Lumber Co., P. O. Box 1282, Sacramento, Calif.

Farrini

LOGGING

Chairman—Fred C. Simmons, U.S.F.S., 102 Motors Ave., Upper Darby, Pa.

Vice Chairman—Paul M. Dunn, St. Regis Paper Co., 150 East 42nd St., New York 17, N. Y.

J. A. Doyle, Forest Products Laboratory of Canada, Ottawa, Ont., Canada

R. O. Gustafson, Westvaco Experimental Forest, Georgetown, S. C.

Leland Hooker, Michigan College of Mining and Technology, Houghton, Mich.

Bruce Mety, Southern Lumber Co., 30 Davenport St., Warren, Ark.

E. E. Matson, Pacific Northwest Forest Experiment Sta., Box 4059, Portland 8, Ore.

David E. Herrick, Carbondale Forest Products Res. Center, Central States Forest Experiment Station, P. O. Box 760, Carbondale, Ill.

W. E. McCraw, Roddis Plywood, Canada

R. F. Grah, School of Forestry, Univ. of California, Berkeley, Calif.

Covach

LUMBER MANUFACTURE

Chairman—Milton H. Mater, Mater Engineering, P.O. Box 236, Corvallis, Ore.

Vice-Chairman—E. P. Ivory, Ivory Pine Co., Box 116, Dinuba, Calif.

Steering Committee

Area I—K. C. Compton, Syracuse University, Syracuse, N. Y.

Area II—A. Clevenger, P.O. Box 471, Corley Mfg. Co., Chattanooga 1, Tenn.

Area III—Peter Johnson, Calif. Redwood Ass'n., 521 3rd St., Eureka, Calif.

Area IV—P. Thomas, College of Forestry, University of Washington, Seattle, Wash.

Region 1a—H. F. Staniforth, Staniforth Lbr. & Veneer, Kiosk, Ont.

Region 1b—Siegfried Tolle, Northeastern Forest Products, Pownal, Vt.

Region 2—John Veach, Mgr., Bemis Hardwood Co., Robbinsville, N. C.

Region 3a—John Sims, W. T. Smith Lbr. Co., Chapman, Ala.

Region 3b

Region 4—Prof. W. J. O'Neil, University of Missouri, Columbia, Mo.

Region 5—Richard M. Connor, Pres., Connor Lumber and Land Co., Laona, Wis.

Region 6—Harold Z. White, St. Maries Lbr. Co., St. Maries, Ida.

Region 7—R. A. Blaser, Southwest Lbr. Mills, Inc., P. O. Box 1550, Flagstaff, Ariz.

Region 8—N. T. Shelton, Diamond Match Co., Chico, Calif.

Region 9—Peter Johnson, California Redwood Ass'n., 521 Third St., Eureka, Calif.

Victor H. Clausen, Holmes Eureka Lbr. Co., Box 1001, Eureka, Calif.

Region 10a—Stephen Batori, Controls & Communications Co., 1695 1st Ave. W., Eugene, Ore.

Region 10b—Jack Pfeiffer, Oregon Forest Products Lab., Corvallis, Ore.

Region 11—Paul Heller, Pacific Pine Co., Ltd., New Westminister, B. C.

Region 12

Region 13a—G. E. Bell, Forest Products Lab. of Canada, Ottawa, Ont.

Region 13b

Region 14

Region 15—W. L. Lear, Crossett Lumber Co., Crossett, Ark.

Norman C. Bye, Henry Disston Division, H. K. Porter Co., Inc., Philadelphia 35, Pa.

David E. Herrick, Forest Research Center, Carbondale, Ill.

Fred C. Simmons, Chairman, FPRS Logging Division, N. E. Forest Exp. Sta., 402 Motors Ave., Upper Darby, Pa.

Covach

MERCHANDISING

Chairman—R. D. Pauley, Weyerhaeuser Timber Co., P. O. Box 1645, Tacoma, Wash.

Vice-Chairman—George E. Olson, The Dow Chemical Co., Midland, Mich.

Hardboard—J. J. Allegretti, Masonite Corp., 111 W. Washington St., Chicago 2, Ill.

Particle Board—Robert Miller, Weyerhaeuser Sales Co., 1st National Bank Bldg., St. Paul 1, Minn.

Insulating Board—

Plywood—John Ritchie, Douglas Fir Plywood Ass'n., 1119 A St., Tacoma, Wash.

Lumber—Arthur Lahey, Weyerhaeuser Sales Co., 2062 W. First Nat'l. Bank Bldg., St. Paul 1, Minn.

G. H. Smith, State Univ. of New York College of Forestry, Syracuse 10, N. Y.

Pulp, Paper and Fiberboards—

Covach

PACKAGING

Chairman—A. R. Tegge, Jr., Quartermaster Food & Cont. Inst., 1819 W. Pershing Rd., Chicago 9, Ill.

QUALITY CONTROL

Howie

Chairman—Charles Latimer, Nickey Brothers, Inc., 2700 Summer Ave., Memphis 12, Tenn.

Vice-Chairman—A. C. Barefoot, School of Forestry, North Carolina State College, Raleigh, N. C.

James S. Bethel, School of Forestry, North Carolina State College, Raleigh, N. C.

Charles A. Bicking, Mgr., Quality Control Branch, Research & Development Div., Carborundum Co., Niagara Falls, N. Y.

Aubrey E. Wylie, Department of Forest Products, Michigan State University, B-4 South Campus, East Lansing, Mich.

Ben S. Bryant, School of Forestry, University of Washington, Seattle 5, Wash.

R. C. Calahan, % Singer Mfg. Co., Ltd., Singer Clydebank, Scotland

Peter Johnson, California Redwood Ass'n., 521 Third St., Eureka, Calif.

R. H. Ripley, Douglas Fir Plywood Ass'n., 1119 A St., Tacoma, Wash.

Robert J. Hader, North Carolina State College, Raleigh, N. C.

VENEER AND PLYWOOD

Chairman—John L. Butler, Hardwood Plywood Institute, 1012 Crescent Ave., N. E., Atlanta, Ga.

Vice-Chairman—John F. Lutz, U. S. Forest Products Lab., Madison, Wis.

Committee

John Ritchie, Douglas Fir Plywood Ass'n., 1119 A St., Tacoma, Wash.

Specialists in

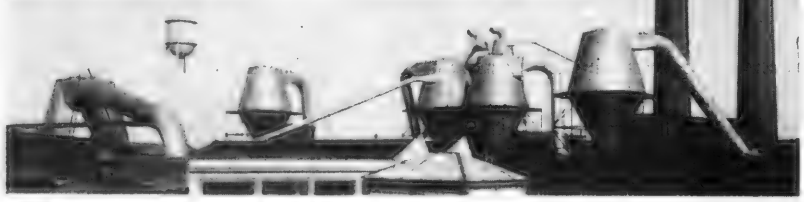
SHAVINGS & SAWDUST COLLECTING SYSTEMS

OLD SYSTEMS and FANS REBUILT

Leaders Since 1876

THE ALLINGTON & CURTIS MFG. CO.

1810 HOLLAND AVE. SAGINAW, MICH.



J. L. BUTLER

J. R. ROBERTS

R. W. Peterson, Forest Products Laboratories Div., Forestry Branch, Dept. of Northern Affairs & Nat'l. Resources, Ottawa, Ont., Canada

James Bethel, School of Forestry, North Carolina State College, Raleigh, N. C.

James R. Roberts, Development Center, Weyerhaeuser Timber Co., Longview, Wash.

Charles H. White, Wolverine Finishes Corp., 836–850 Chicago Dr., S. W., Grand Rapids, Mich.

Peter J. Stern, Southern Plywoods, Inc., P. O. Box 448, Greenville, Fla.

WOOD COMPOSITION BOARD

Chairman—J. R. Roberts, Celotex Corp., 120 S. La Salle St., Chicago, Ill.

Vice-Chairman—A. L. Mottet, Long-Bell Division, International Paper Co., Longview, Wash.

E. M. Williston, Technical Center, Weyerhaeuser Timber Co., Longview, Wash.

G. G. Marra, Washington State Institute of Technology, Pullman, Wash.

W. C. Lewis, U. S. Forest Products Lab., Madison, Wis.

H. C. L. Miller, Miller Hofft, Inc., Richmond, Va.

E. S. Johnson, N. C. State College, Raleigh, N. C.

J. F. Hamilton, Michigan College of Mining and Technology, Houghton, Mich.

WOOD DRYING DIVISION

Chairman—S. B. Preston, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

Vice-Chairman—John W. McMillen, Forest Products Laboratory, Madison, Wis.

Leif D. Espenas, Oregon Forest Products Laboratory, Corvallis, Ore.

Jack Pfeiffer, Oregon Forest Products Laboratory, Corvallis, Ore.

W. J. Delmhorst, Delmhorst Instrument Co., 607 Cedar St., Boonton, N. J.

Eric Ellwood, Yale School of Forestry, 205 Prospect St., New Haven, Conn.

H. B. Gatslick, State University College of Forestry, Syracuse 10, N. Y.

F. W. Guernsey, Forest Products Laboratory, Univ. of British Columbia, Vancouver, B. C., Canada

A. C. Knauss, P. O. Box 4059, Portland, Ore.

Edwin Knight, Western Pine Ass'n., 7733 S.E. 13th Ave., Portland, Ore.

E. D. Marshall, 541 Humason Ave., Lufkin, Texas

R. S. Millett, Forest Prod. Lab., Ottawa, Ont., Canada

Harold Rhodes, J. W. Bolton & Sons, Lawrence, Mass.

R. W. Shepherd, Federal Prison Industries, Rt. 1, Chillicothe, Ohio

H. H. Smith, Calif. Forest & Range Exp. Sta., P. O. Box 245, Berkeley 1, Calif.

M. A. Taras, Southeastern Forest Exp. Sta., School of Forestry, North Carolina State College, Raleigh, N. C.

[illegible]at Williams, Jr., Moore Dry Kiln Co., Box 4248, Jacksonville, Fla.

Herb Geisenheyner, Coast Kiln and Lumber Co., 4320 Exchange Ave., Vernon, Calif.

W. J. Tomford, James E. Stark Co., P. O. Box 4665, Memphis, Tenn.

G. B. Shivery, Agric. Ext. Service, Univ. of Tenn., Knoxville, Tenn.

Mack Frost, Kaibab Lumber Co., Fredonia, Ariz.

C. W. Hefner, National Cash Register Co., Dayton, Ohio

Harry E. Troxell, Colorado A & M. Fort Collins, Colo.

Dean Boyd Richards, Alabama Polytechnic Institute, Auburn, Ala.

David Irwin, University of New Brunswick, Fredericton, N. B.

J. B. Huffman, University of Florida, Gainesville, Fla.

Norman Higgins, Michigan State Univ., East Lansing, Mich.

R. C. Rietz, Forest Products Laboratory, Madison, Wis.

R. H. Elliott, Standard Dry Kiln Co., Indianapolis, Ind.

WOOD FINISHING

Chairman—F. H. Thomas, Sherwin–Williams Co., 115th St. & Cottage Grove Ave., Chicago 28, Ill.

Vice-Chairman—D. G. Lubeck, Hammond Organ Co., 2915 North Western Ave., Chicago 18, Ill.

P. F. De Saix, Carborundum Co., Box 1574, High Point, N. C.

Don E. Laughnan, U. S. Forest Products Lab., Madison, Wis.

George A. Lenaeus, Southern Varnish Corp., P. O. Box 1004, Roanoke, Va.

Robert S. Taub, Sherwin–Williams Co., 601 Canal Road, Cleveland 13, Ohio

W. E. Martin, Grand Rapids Varnish Corp., 1350 Steele Ave., S. W., Grand Rapids 2, Mich.

WOOD MACHINING

Chairman—N. C. Bye, Henry Disston Div., H. K. Porter Co., Inc., Philadelphia 35, Pa.

Vice-Chairman — Robert J. Hoyle, Jr., College of Forestry, New York State Univ., Syracuse 10, N. Y.

Secretary—T. C. Weiil, Carboloy Dept., General Electric, 11177 E. Eight Mile Rd., Detroit, Mich.

Sub-Committees

Sanders
Machinery
Tools
Laboratories & Universities
Users

WOOD PRESERVATION

Chairman—Charles S. Walters, Illinois Agric. Exp. Station, 219 Mumford Hall, Urbana, Ill.

Vice-Chairman—A. H. Bishop, New York State Univ., College of Forestry, Syracuse 10, N. Y.

Advisory Committee

E. A. Behr, Chapman Chemical Co., Mallory Sta., Box 3158, Memphis, Tenn.

Ralph H. Bescher, Ass't. to V.P. & Gen Mgr., Wood Preserving Div., Koppers Company, Inc., Pittsburgh 19, Pa.

G. A. Garratt, Yale Univ., School of Forestry, 205 Prospect St., New Haven 11, Conn.

Ira Hatfield, Wood–Treating Chemicals, Inc., 5137 Southwest Ave., St. Louis 10, Mo.

R. D. Graham, Oregon Forest Products Lab., 17th & May Streets, Corvallis, Ore.

S. B. PRESTON

F. H. THOMAS

W. C. Hopkins, School of Forestry, Louisiana State Univ., Univ. Station, Baton Rouge, La.

P. B. Mayfield, Barrett Div., Allied Chemical & Dye Corp., 40 Rector St., New York, N. Y.

George Fahlstrom, Osmose Wood Preserving Co., 980 Ellicott St., Buffalo, N. Y.

R. M. Lindgren, U. S. Forest Products Laboratory, Madison 5, Wis.

Annual Report Committee

Methodology

Pressure Field and Solvent Recovery:
M. S. Hudson, P. O. Box 2451, Spartanburg, S. C.

Other Treating Methods:

Other Than Pressure or Hot-Cold Methods:
G. G. Garlick, Protection Products Mfg. Co., Box 747, Kalamazoo 99, Mich.

AWPA Methods:
P. B. Mayfield, Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., New York, N. Y.

Test Methods:
Ralph Van Allen, Wood-Treating Chemicals Co., 5137 Southwest Ave., St. Louis, Mo.

Proposed New Chemicals

J. O. Blew, U. S. Forest Products Lab., Madison 5, Wis.

F. J. Meyer, Dow Chemical Co., Midland, Mich.

R. A. Zabel, New York State College of Forestry, Syracuse 10, N. Y.

Activities by Regions for 1955–56

Northeastern United States
H. W. Hicock, Conn. Agric. Exp. Sta., Box 1106, New Haven, Conn.

Mid-Continent
C. Miles Burpee, American Wood Pres. Inst., 111 W. Washington St., Chicago 3, Ill.

E. A. Behr, Chapman Chemical Co., Mallory Sta., Box 3158, Memphis, Tenn.

South and Southeast
Mark Lehrbas, Southern Forest Exp. Sta., 2026 St. Charles Ave., New Orleans, La.

Rocky Mountain and Inland Empire
L. A. Mueller, Rocky Mountain Forest Exp. Sta., Ft. Collins, Colo.

E. S. Kotok, Intermountain Forest and Range Experiment Station, Ogden, Utah

Pacific Area
R. D. Graham, Oregon Forest Products Lab., 17th & May Sts., Corvallis, Ore.

Liaison-Association and Other Activities
J. N. Roche, Tar Products Div., Koppers Company, Inc., 1200 Koppers Bldg., Pittsburgh 19, Pa.

Wood Products Preservation
G. G. Marra, Div. of Industrial Research, Wash. State Institute of Tech., Pullman, Wash.

LITERATURE CITATIONS

Ira Hatfield, Wood–Treating Chemicals, Inc., 5137 Southwest Ave., St. Louis 10, Mo.

FPRS News-Digest, Continued

NEW PUBLICATIONS

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

Partial List of Publications for Furniture Manufacturers, Woodworkers and Teachers of Wood Shop Practice. June 1957. Report No. 1775.

List of Publications on Logging, Milling, and Utilization of Timber Products. July 1957. Report No. 790.

List of Publications on Wood Preservation. June 1957. Report No. 704.

Cold Soda Pulping of Aspen by Improved Methods. K. J. Brown and W. H. Monsson. Reprint from Tappi, Vol. 39, No. 8.

Methods of Determining the Specific Gravity of Wood. Technical Note B-14.

The Persistence of Wood Xylan and Mannan Through Successive Prehydrolysis. Pulping, Purification, and Nitration. R. L. Mitchell, M. A. Millett, W. E. Moore, and J. F. Saeman. Reprint from Tappi, Vol. 39, No. 8.

Recycling Liquor Systems for Cold Soda Pulping. P. K. Baird, G. Ceragioli, and K. J. Brown. Compares two countercurrent systems for the reuse and recycling of pulping liquors and wash waters in the cold soda pulping of aspen. Report No. 2059.

Methods of Handling Lumber at the Rear of the Mill. One of the Small Sawmill Improvement series, dealing with the use of trucks, conveyors, and skids to handle lumber at the rear of the mill. Report No. 899–30.

Neutral Sulfite Corrugating Boards from Southern Red, Scarlet, and Black Oaks. E. L. Keller and D. J. Fahey. Presents the results of pulping and papermaking tests of three southern red oaks. Report No. 2067.

Developments in Debarking. E. W. Fobes. Reports on the progress made in the development and use of debarking equipment, particularly the use of debarkers by sawmills. Report No. 2071.

News and Views of this Kiln Drying Business—How Can Sticker Stain in Hardwood Lumber be Prevented? E. C. Peck. Report No. 1769–23.

Coatings for the Prevention of End Checks in Logs and Lumber. J. M. McMillen. Report No. 1435 (revised).

Pollution of Streams from Pulp and Paper Mills. E. R. Schafer. Report No. 1207 (revised).

Sen. B. F. Kukachka. One of the foreign wood series dealing with the Japanese hardwood Sen, belonging to the ginseng family, which is also known as hari-gari, Castor Arabia, and nakora. Report No. 1979 (revised).

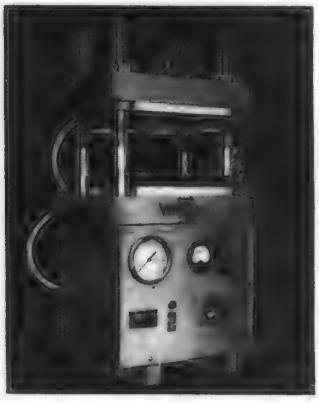
Devices that Measure and Control Temperature in Dry Kilns. K. E. Kimball. Report No. 1654 (revised).

Method for Determining Tensile Properties of Paper. V. C. Setterholm and E. W. Kuenzi. Reports results of tensile tests made on straight specimens of five widely different types of paper, using the crosshead movement of the testing machine to measure specimen elongation. Report No. 2066.

Relationship of Locality and Rate of Growth to Density and Strength of Douglas-Fir. J. T. Drow. Describes the effect of growth rate and percentage of summerwood on density and strength properties. Report No. 2078.

THE WABASH 30-TON LABORATORY PRESS IS

IDEAL FOR WOOD PRODUCTS RESEARCH AND TESTING



- For laminating, parquetting, small run and experimental veneer work, testing adhesives, and other high pressure jobs around wood working plants and laboratories.
- Full 60,000 lbs. pressure exerted rapidly or gently. Hydraulic unit manually operated with minimum effort.
- Accurate paralleling of platens accomplished because guide holes are precision bored.
- Platen area is 144 sq. inches. Width between columns is 14". Daylight opening is 10". Stroke 10".
- Heated platens have close temperature control. Removable for work not requiring heat with pressure.
- Control cabinet console designed to permit easy access to hydraulic unit and other internal parts. Controls are away from heat zone.

Ask for names of users and wood product applications.

Ask for literature on 3 to 50 ton units.

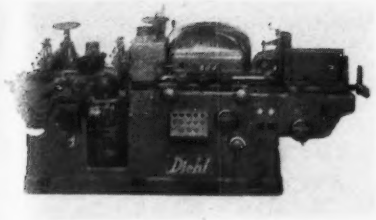
WABASH METAL PRODUCTS CO.
1504 MORRIS ST., WABASH, INDIANA.

Tree Farming for Today and Tomorrow

SIMPSON LOGGING COMPANY

Shelton and McCleary, Washington

FPRS News-Digest, Continued



New Size Moulders

Two new size moulders, six and eight inches, have been released for production by the G. M. Diehl Machine Works, Inc. Each of the two sizes is available in three models: with four cutterheads; with two top heads, making five in all; and with two bottom heads, making five in all. Both size machines feature hopper feeds that utilize ball and roller-bearing construction throughout.

Information on the new size moulders is available in Bulletin M–957 from the G. M. Diehl Machine Works, Inc., Wabash, Ind.

New Airveyor Booklet

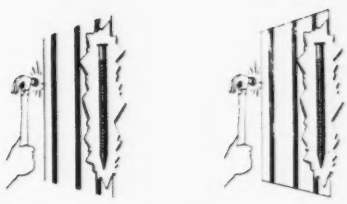
Operation of the Airveyor, as used in the pulp and paper mill industry for handling process chemicals, chips, sawdust and hog fuel, are described in a new 12-page bulletin obtainable from Fuller Co., Catasauqua, Pa. Bulletin A-17 reports on ten Airveyor operations now being carried out by companies in the U. S., Alaska, and Canada. Included are a schematic diagram for each system described and photographs for illustration.

Cope and Tenon Heads Bulletin

The use and application of cope and tenon heads is explained and illustrated in a new 16-page booklet put out by the Wisconsin Knife Works, Beloit, Wis. Special attachments and applications are illustrated in this cutterhead bulletin No. 500. Copies are available free by writing Box 869, to the above address.

"Timber" Folder

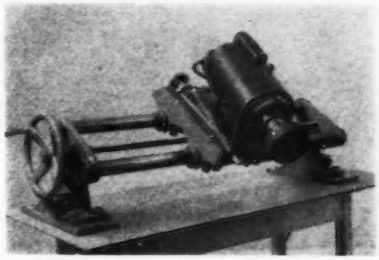
A new folder, "Timber", has been published by the Western Pine Assoc., and features an easy tree identification guide for the 10 commercial timber species of the region. Latest statistics on timber supply and lumber production are also included. Retailers, groups and individuals can obtain up to 100 copies free from the Western Pine Assoc., Yeon Bldg., Portland 4, Ore.



Nail for Interior Hardboards

A hardened steel nail designed for application of interior hardboards has been announced by Independent Nail & Packing Co., Bridgewater, Mass. Called the Stronghold Annular Thread Hardboard Nail, it is made of high-carbon steel, heat-treated and tempered to drive into either ⅛ inch or ¼ inch interior hardboard without bending or breaking.

The threads reportedly "lock" with the fibers of the wood into which the nails are driven, thereby providing a permanently tight fastening and avoiding loosening and "popping".



High-Speed Grinder

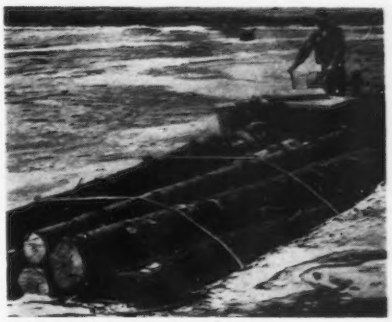
A high-speed motor driven band wheel grinder for both band mill and resaw wheels has been announced by the Hanchett Mfg. Co., Big Rapids, Mich., and Portland, Ore.

This "Hanchett–Mater Walker High–Speed Grinder" reportedly will grind wheels while they are running at full operating speeds. Descriptive bulletin with detailed specifications is available free from the Hanchett Manufacturing Co., Big Rapids, Mich.

New Kiln Described in Folder

Operating principles and construction features of a new lumber dry kiln are outlined in a folder published by the Wel–Dri Kiln Co. Features described in the bulletin are 300 fpm air movement over all surfaces of the lumber, and close control of temperature and moisture. Made of concrete, the kiln contains pre-lubricated equipment.

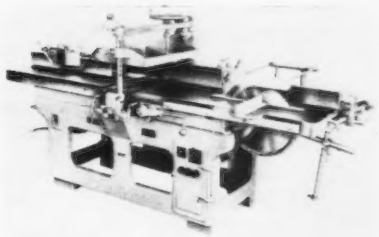
The kiln reportedly can be constructed in any size. For copies of the folder, which contains diagrammatic illustrations on the kiln operation, write the Wel–Dri Co., 730 S. Third St., Box 2834, Memphis 2, Tenn.



Log Bundling Method

Elk Lumber Co., Medford, Ore., now bundles its logs with steel strapping, and reportedly has doubled storage capacity of their 18-acre pond. The firm uses a method developed jointly by Elk Lumber and Acme Steel Co. that allows use of the underwater as well as surface areas of the pond.

As each load is measured by the scaler, the truck driver passes two lengths of 2 by .050 inch heavy duty steel strapping around the load, one fourth of the length from each end. Slack is left in each strap to allow for buoyancy of the immersed bundles.



Combination Woodworking Machines

Combination woodworking machines, manufactured in Sweden, have been announced for distribution in the U. S. by Stanco Mfgs. & Sales, Inc., Los Angeles, Calif. Known as Stenbergs Universal Woodworkers, they are made in two models, both combination jointers, surface and thickness planers, circular saws, spindle moulders, borers, mortisers, and disc sanders. On one model, the spindle moulder and planer feed mechanisms are driven by separate motors. Literature on the machines is available from Stanco Mfgs. & Sales, Inc., 1931 Pontius St., Los Angeles 25, Calif.

WILCO REFUSE BURNER

Three Models. Complete Range of Sizes. Lowest-cost installation. Prefabricated, one-piece panels. Exclusive triple-draft. Sizing engineers available to you.

WILCO MACHINE WORKS, INC.
Municipal Airport • Memphis, Tenn.
P. O. Box 3722 • WHitehall 8–4555

PROFESSIONAL CARD

MATER ENGINEERING

Sawmill—design, modernization, automation
Product Development—surveys, reports

P. O. Box 410
Corvallis, Oregon Plaza 3–8336

GRANT B. SHIPLEY

Consulting Engineer

3010 KOPPERS BUILDING

PITTSBURGH 19, PENNSYLVANIA

Wood Treating Plants
Mining Plants

PAUL WATTS, INCORPORATED

Distributors and Sales Engineers . . . Forest Products

Furniture Dimension—Cut Stock—Box Shook—Pallets—Lumber

304 Keith Building • MAin 1–5680

Cincinnati 2, Ohio

For SPECIALIZED Inspection Service . . . Contact

—WILLIAMS—

- Inspection of cross ties, lumber, piling, poles and cross arms.
- Inspection of the preservative treatment of these timber products.
- Analyses of wood preservatives.

Our years of experience is your safeguard.

A. W. Williams Inspection Co., Inc.
Main Office and Laboratories: Mobile, Ala.
ESTABLISHED 1921—MEMBER A.C.I.L.
Inspectors Stationed Throughout United States.

Index to Advertisers

	Page
Allington & Curtis Manufacturing Co.	100-A
American Cyanamid Co.	2nd Cover
American–Marietta Co.	11-A
Armstrong Machine Works	82-A
Barrett Division—Allied Chemical & Dye Corp.	36-A
Behr–Manning Co.	5-A
Black Brothers Co.	7-A
Buss Machine Works	3-A
Carr, Adams & Collier Co.	90-A
Cascades Plywood Corp.	88-A
Catalin Corporation of America	40-A
Chapman Chemical Co.	6-A
CKL Machinery Co.	90-A
Coe Manufacturing Co.	20-A
G. M. Diehl Machine Works	14-A–15-A
Enterprise Co.	85-A
Fastener Corp.	89-A
Filer & Stowell Co.	13-A
Fjellman American, Inc.	4th Cover
Gamble Brothers Co.	84-A
Greenlee Bros. & Co.	4-A
Handy Manufacturing Co.	81-A
Harshaw Chemical Co.	94-A
Hawker Manufacturing Co.	77-A
Hyster Co.	66-A
Independent Nail & Packing Co.	80-A
Kirk & Blum Manufacturing Co.	76-A
Koppers Co., Inc.—Chemical Division	8-A
Laucks Laboratories, Inc.	96-A
Lodge & Shipley Co.	78-A
C. M. Lovsted & Co.	24-A
Maple Flooring Manufacturers Association	84-A
Mater Engineering	104-A
Mattison Machine Works	3rd Cover
Mereen–Johnson Machine Co.	26-A
Moisture Register Co.	99-A
Monsanto Chemical Co.	12-A
Moore Dry Kiln Co.	16-A
D. J. Murray Manufacturing Co.	70-A
National Casein Co.	21-A
Newman Machine Co.	86-A
Onsrud Machine Works, Inc.	83-A
Orr & Sembower, Inc.	19-A
Orton Machine Co.	88-A
Parkwood Laminates, Inc.	91-A
Perkins Glue Co.	17-A
Ply-Curves, Inc.	98-A
Reichhold Chemicals, Inc.	2-A
B. M. Root Co.	28-A
St. Paul & Tacoma Lumber Co.	44-A
Saranac Machine Co.	79-A
Grant B. Shipley	104-A
G. Siempelkamp & Co.	27-A
Simpson Logging Co.	102-A
Soderhamn Machine Manufacturing Co.	75-A
Solem Machine Co.	46-A
Southern Screw Co.	74-A
Standard Dry Kiln Co.	88-A
Stetson–Ross Machine Co.	22-A
Texas Creosoting Co.	86-A
Timber Engineering Co.	68-A
United–Carr Fastener Corp.	25-A
United Shoe Machinery Corp.	72-A
U. S. Plywood Corporation	42-A
Wabash Metal Products Co.	103-A
Washington Iron Works	9-A
Paul Watts, Inc.	104-A
The Wel–Dri Co.	95-A
Weyerhaeuser Timber Co.	43-A
Baxter D. Whitney & Son, Inc.	95-A
Wilco Machine Works, Inc.	104-A
A. W. Williams Inspection Co.	104-A
Williams Patent Crusher & Pulverizer Co.	87-A
Williams–White & Co.	86-A
Wisconsin Foundry & Machine Co.	84-A
Wood Treating Chemicals Co.	93-A
S. A. Woods Machine Co.	18-A
Woodworking Machinery Manufacturers Association	23-A
Yates–American Machine Co.	10-A

how
MATTISON
Quality-Built
Equipment
jumps plant
profits

MATTISON DEPENDABILITY HELPS KEEP CONVEYOR-FED PRODUCTION RUNNING SMOOTHLY

at Link-Taylor Corporation, Lexington, N. C.

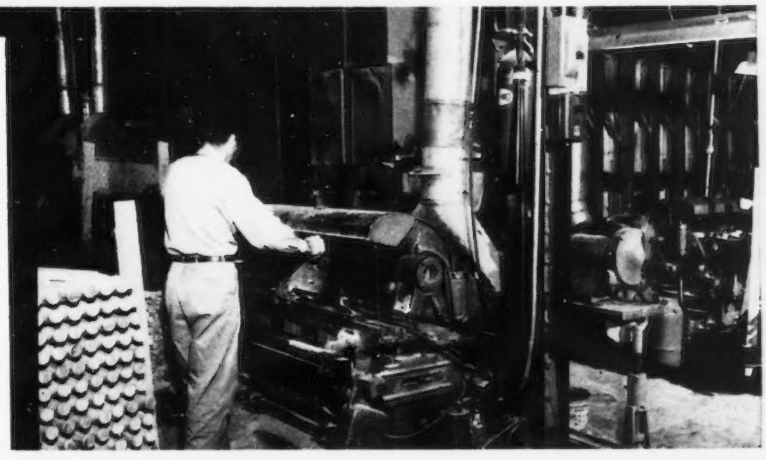
If profitable production in your shop depends on uninterrupted flow of parts, then you will be interested in the performance record of these Mattison woodworking machines at the Link-Taylor Corporation. Three Mattison fast-feed, straight-line rip saws, two automatic shaping lathes, and two high-speed electric moulders have been producing quality parts for fine bedroom furniture for more than five years, "with less than eight hours' downtime due to maintenance," according to Mr. Archie L. Hodges, general superintendent.

"Quality comes first in our production, but production is also very important," says Mr. Hodges, "that's why we buy equipment that gives us both." Excellence of design and construction of Mattison woodworking machinery makes this kind of profitable performance and quality production possible in leading woodworking plants everywhere. For information on how these machines can help boost your plant profits, ask your Mattison dealer for a copy of "Woodworking Production Reports," just off the press.

MATTISON
MACHINE WORKS
ROCKFORD, ILL. U.S.A.

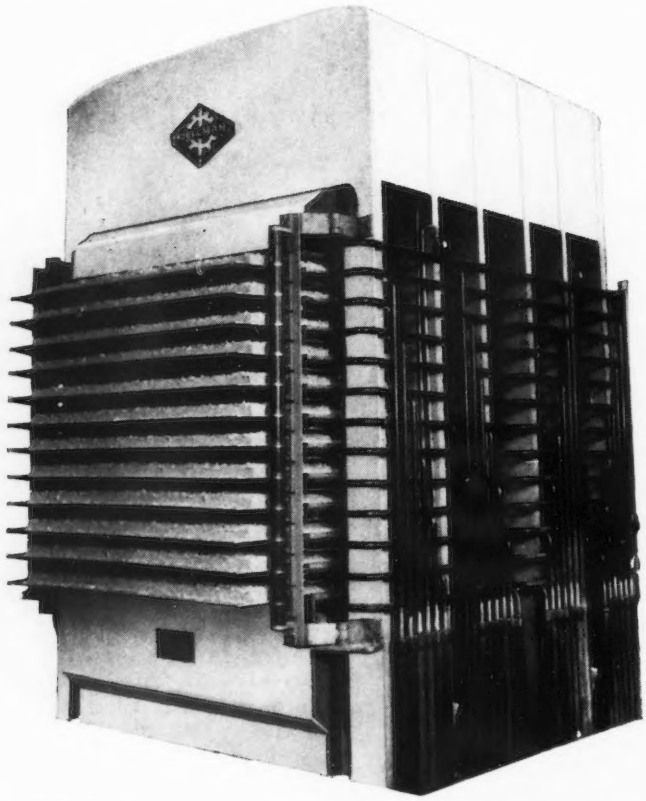
MATTISON
WOODWORKING
MACHINERY

"Built better...to produce better quality"



from Particles to Profits

FJELLMAN AMERICAN HYDRAULIC HOT PRESSES



More than ten years research and experience with particle-type board presses—and a close association with top manufacturers here and abroad—has resulted in a Fjellman American hot press capable of producing the finest particle-type board by wet or dry processes, either chip, flake, shaving or fibre.

As with all Fjellman American presses, here's a press built to the highest standard of strength and accuracy for long service and minimum maintenance. Each is precision-engineered from fine Swedish virgin steel. Each has box-type frame, light floor-loading properties, American instruments, wiring and hardware.

Available in a wide range of sizes to accommodate the factory interested in capitalizing on its present wood-waste or the largest manufacturer of wood-composition board.

WRITE FOR CATALOG No. 100-A covering our complete line of industrial hydraulic presses.

Ask your consulting engineer about our presses or write us for complete information on presses readily adapted to your specific particle-type board manufacture.

FJELLMAN AMERICAN

FJELLMAN AMERICAN INC.

P. O. Box 1205 • Joliet, Illinois

Manufacturers of a complete line of "hot" and "cold" presses for the furniture, plywood and plastic industry